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CONTENTS

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CHANGES IN THE NUMBERING OF REVIEW CHARTS

Beginning with this issue the series of Review charts will be numbered as follows:

Chart I. Departure (°F.) of the mean temperature from normal.
Chart II. Tracks of centers of anticyclones.
Chart III. Tracks of centers of cyclones.
Chart IV. Percentage of clear sky between sunrise and sunset.
Chart V. Total precipitation (inches)
Chart VI. Isobars at sea leavel, isotherms at surface, and prevailing winds.
Chart VII. Total snowfall (inches), cold season only.

The charts of the North Atlantic Ocean will continue as at present, starting with No. VIII.

CORRECTIONS

Review, September, 1927:

Page 431, column 2, the paragraph commencing, "In connection with this typhoon," relates to the typhoon of Byler (September 17–20), and, with the rest of the article, should follow the table at the middle of the column, preceding the subtitle, "Three typhoons between the Bonins and Japan."

Review, November, 1927:

Page 492, first column, second paragraph, beginning of last line, "145" should be "135."

MONTHLY WEATHER REVIEW

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THE CLIMATE OF CHINA[1]

By C. E. KOEPPE and N. H. BANGS

China, situated as it is along the eastern and southeastern margin of a great continent, has a climate dominated by the monsoons. These are winds which reverse in direction from summer to winter. Thus, the winds of China are prevailingly from a southeasterly quarter in summer and a northwesterly quarter in winter; that is, they tend to blow from the sea to the land in summer and from the land to the sea in winter. These monsoonal winds determine to a large extent both the ranges in temperature from summer to winter and the distribution of precipitation throughout the year. Cold winters and hot summers, especially in northern China, and the frequent droughts and floods, which occur chiefly in spring and summer, are closely tied up with these reversals of wind direction.

There are, however, many other factors which control in varying degrees the climate of China. Among these are the passage either across or very near the country of rather weak cyclonic storms, especially in spring, and the movement of typhoons, which are severe cyclonic storms much like the familiar West Indian hurricanes and which are most pronounced in September; these are felt less in northern China than in central and southern China. The rather high mountain ranges of the southeastern portion of the country and the loftier mountains and plateaus of the west and northwest modify the climate largely because of their barrier effects. This is shown by the lighter rainfall back from the coast in the southeast and by the lower rainfall and higher temperatures of the Great Szechwan Basin in summer. It is undoubtedly a fact, too, that China's winters would be more severe than they already are if it were not for the protection offered by the mountains to the west and north against the extreme cold of the interior. Fortunately for China, these cold blasts are rendered appreciably warmer by compression as they descend to the lowlands.

Finally, the control of the ocean waters over the climate of this land can not be neglected, for they not only furnish abundant vapor for the summer showers but they also serve to moderate the temperatures of summer or whenever the winds are on shore. These effects are no doubt rendered more appreciable by the warm Kuro current which moves very close to the continent at Formosa.

The reason for the monsoons of China (and they either dominate or have an important bearing upon the climate of all southeastern Asia) is at once apparent. Here is a great land mass with a great arid region in the interior just north of the Himalaya Mountains. This arid region comprises much of Mongolia, Tibet, and southern Siberia and extends far westward into Asia Minor. In winter the eastern part of this region becomes intensely cold due to rapid radiation from the land because of the clear, dry air. Thus, the air here is relatively dense as compared with the moist, warm air over the ocean waters to the south; that is, the barometric pressure over the land is "high" while that over the ocean is "low." Hence the air over the land tends to move in a southerly direction, in so far as China is concerned, and to replace the warmer and moister, and hence lighter, air over the water. In summer, however, conditions are reversed, although contrasts are not so great. The land over the interior under the intense insolation which results from the longer days, from the more vertical rays of the sun, and from the absence of moisture, becomes relatively hot. The air is greatly heated and expanded. Its density therefore is much less than that of the air over the relatively cool ocean to the southeast. Hence a high-pressure area forms over the ocean and a low-pressure area over the land, with a resultant movement of the air from the sea to the land.

The story is not quite so simple as this would seem to indicate. The barometric pressure over the land is not consistently high in winter and low in summer; it is evident, too, that the change from summer to winter conditions and vice versa are not abrupt. Many factors enter in to modify this ideal distribution of pressure during the winter and summer seasons. It follows, then, that the winds are somewhat variable.

The data on wind directions, as well as the other climatological elements, are very meager. Co-ching Chu, of the National Southeastern University at Nanking, in his study of the climate of Nanking, suggests that the wind directions of North Saddle Island, a small island near the mouth of the Yangtze River, may be taken as fairly indicative of wind directions all along the east coast. These show that in January winds blow 50 per cent of the time from the northwest and hence only 50 per cent of the time from all other directions combined, in April they blow 55 per cent of the time from the northeast and east, in July 50 per cent of the time from the southeast and south, and in October 50 per cent of the time from the north and northeast. Winds rarely blow from the west, and very infrequently from the southwest. This is in striking contrast to the eastern portion of the United States. Local topography, the presence of land and sea breezes, and the passage of cyclones and typhoons would prevent these conditions from obtaining throughout China. The few other records available seem to show much the same wind distribution as at North Saddle Island. Thus, the winds in July at Cheefoo seem to blow mainly from a southerly direction and in January from a northwesterly direction; at Amoy they are from a southerly direction in July and from a northeasterly direction in January.

The most marked effects of the monsoonal winds are shown, of course, on the annual range of temperature and precipitation. Because of these outflowing winds in winter, all China shivers down to the tip of its toes—even to Hong Kong, the world's coldest subtropical city. Conversely, the inflowing winds of summer give to the country a very thorough and uniform roasting in July and August. It is a land, then, of remarkable contrasts

[1] Cf. Co-Ching Chu, Rainfall in China. MONTHLY WEATHER REVIEW, 44:270-281.

between winter and summer; these contrasts modified only to a slight degree by the influence of local topography.

These contrasts are most intense in the north, where the severity of the winter is extreme. Mukden, situated in the same latitude and at about the same distance from the coast as Albany, N. Y., has a January mean temperature of only 8°, some 15° colder than its none too tepid American counterpart. Likewise, Tientsin, about the same latitude as Washington, has a January mean 8° colder. In fact, this comparison between stations in China and similarly situated stations in the same latitude in the United States can be carried throughout the whole length of China, and will serve to emphasize the severity of the Chinese winter. Thus, Shanghai on the central coast is 14° colder in winter than Savannah, Ga., its latitudinous American partner. And Hong Kong, on the southern coast, whose coldest month is February with a mean temperature of 58° is some 10° colder than Key West, although the latter is about 3° north of Hong Kong.

Possibly, although we have not had the opportunity to investigate thoroughly, the only advantage that the Chinese cold has over the better known American variety, is its steadiness. The rapid changes from hot to cold, the "bathing suit to fur coat" type so well associated with our New England climate, do not seem to occur so frequently. This appears to be true in the north especially, as the highest temperature recorded at Mukden in January in 10 years was 46°, while temperatures above 60° are not infrequent at Albany. Very likely this is because of the weakness of the winter cyclonic action in northeastern China as compared with that in the northeastern United States. Thus, in China the wind in the coldest months does not blow long enough or strong enough from the south to bring large quantities of warm air very far north, and the rise of temperature on the front of a weak Chinese "low" is not nearly so great as the rise in front of one of the intense "lows" that pass along our northern border in winter. Even if northern China is spared in this respect, yet the steady cold and dryness bring hardship and suffering. In the vicinity of Peking the fierce north winds swoop down upon the city laden with clouds of dust that make life barely endurable, and even at times sweep out to sea and interfere with navigation. And this past winter brought the story of the draft of 200 coolies brought down in open cars from the vicinity of the Great Wall to Peking for work about the city. On arrival they were all shipped back as unsatisfactory; they were all frozen to death.

Farther south in Central China where a southerly wind can more readily raise the temperature, cold waves apparently occur. Thus, in Nanking in 1916 the temperature fell from 50° on January 23 to 13° on the 24th; this drop of 37° comes within our conception of a cold wave. Yet even here the weather remains cold or warm for longer periods than with us. In the northeastern United States the weather unit is two or three days (that is, normally a change in the type of weather is expected every two or three days), while at Nanking it would appear to be a week or 10 days.

A striking fact to be noted is that the central western interior of China is considerably warmer than the eastern coast at the same latitude. For instance, Chengtu in the Szechwan Basin at an elevation of 1,700 feet has a January mean 6° higher than that of Shanghai; and Chungking, in the same region but a little farther south of Chengtu, is 8° warmer than Hangchow on the coast. The eastern coast is open to the uninterrupted sweep of the north winds; but mountain ranges, especially the Tsin Ling Shan, that thrust themselves out eastwardly from the Tibetan Highland as far as the central Honan Province, protect the western sector.

Cold as the winter is, yet spring comes quickly. By February 27 spring has come to Nanking (officially a mean temperature of 43°). By March 26 it has arrived at Cheefoo, and by April 8 at Mukden. This is a rate of advance almost twice as fast as that experienced in the eastern United States. According to Doctor Hopkins, spring advances northward in the United States normally at the rate of 4 days for each degree of latitude; in China the rate is about 2½ days. Chu, in his paper before the recent meeting of the Pan Pacific Science Society, pointed out the interesting fact that spring months—April, May, and June—average about 2° cooler at Shanghai than at Tientsin, which is 500 miles farther north. This anomaly is caused by the depressions which frequently passing down the Yangtze Valley during these months, bring rain and cloudy weather to Central China, but leave north China unaffected.

Spring passes rapidly into summer, and by June practically all stations show mean temperatures of 70° or over, and with July and August come the months of greatest heat over the whole country. These two months show little variation between northern and southern stations. Thus, the July mean at Hong Kong is 82°, at Chungking 82°, at Nanking 81°, and at Mukden 76°. A comparison with the United States shows that northern China is warmer in summer than the corresponding region of the United States; but in the center and south they are about the same. For example, Mukden and Tientsin with mean temperatures of 76° and 79° are, respectively, warmer than Albany and Washington with 73° and 76°; but Nanking with a July mean of 81° is about the same as Savannah with 82°, and Hong Kong with 82° is slightly cooler than Key West with 83½°. In spite of the high mean temperature, absolute maxima of 100° or more are rare. Of the 100 stations reporting at Zikawei Observatory, only 29 have ever reported temperatures as high as this. Of these, the stations in the Szechwan Basin and those around Peking vie with one another in reporting the high temperatures: Ichang and Chungking each have reported temperatures as high as 110°; in northern China, Tangwang has reported 113°, Hienchien 111°, and Tangku 118°, but this last reading is open to suspicion.

It is in summer that the ocean exerts its influence most in affecting the climate of China. Since the winds are prevailingly on shore, the temperature along the shore is everywhere lower than the immediate interior.

After September the thermometer begins to tumble almost as rapidly as it rose in the spring. By November China has become considerably colder than the United States. Mukden is then 10° colder than Albany, Tientsin 5° colder than Washington, and Shanghai 7° colder than Savannah. By December China is once more in the relentless grip of winter. The monthly averages for five places are presented in the diagrams below.

The rainfall of China is quite as remarkable as the course of temperature. As would be expected, a region exposed to cold, dry winds blowing from a high interior plateau would have little if any rainfall while those winds prevailed. On the other hand, winds coming from a moist ocean and blowing across the higher land would certainly cause rather abundant precipitation. Through-

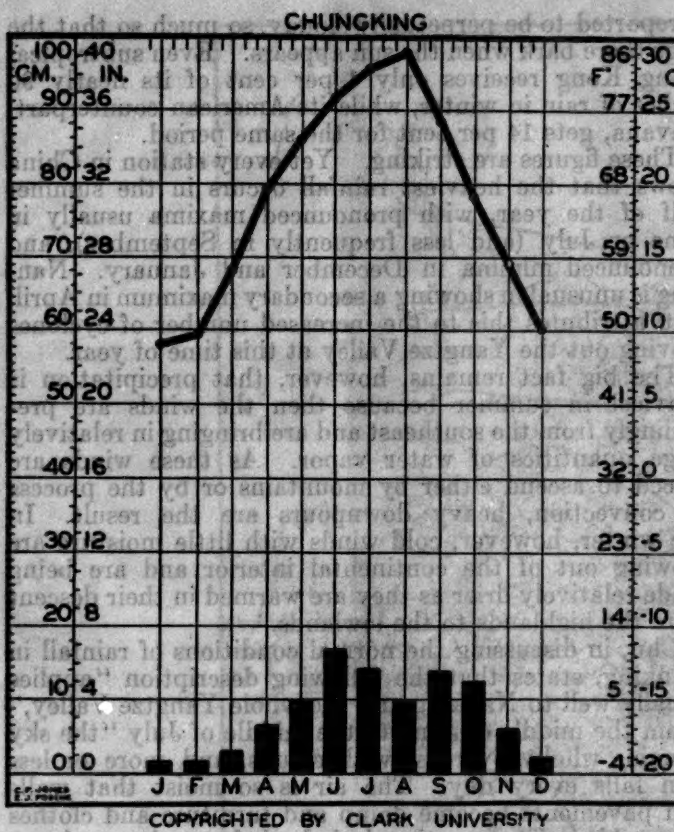

FIG. 1.—Monthly mean temperature and total precipitation at Chungking

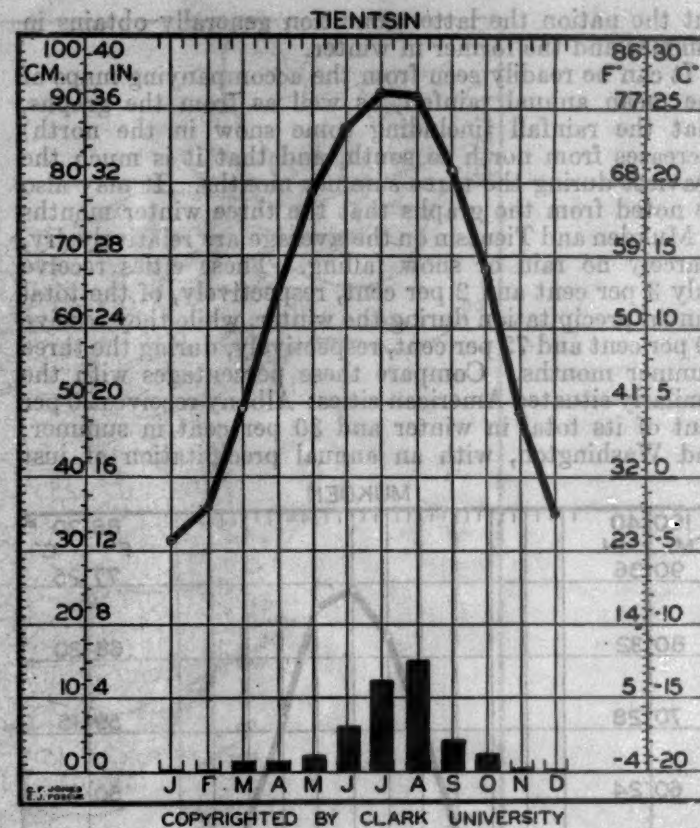

FIG. 3.—Monthly mean temperature and total precipitation at Tientsin

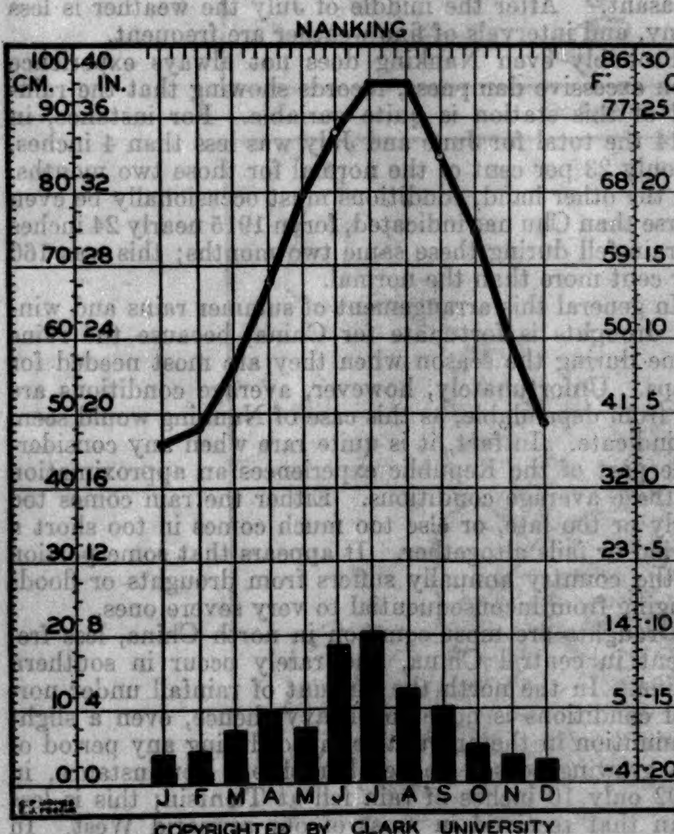

FIG. 2.—Monthly mean temperature and total precipitation at Nanking

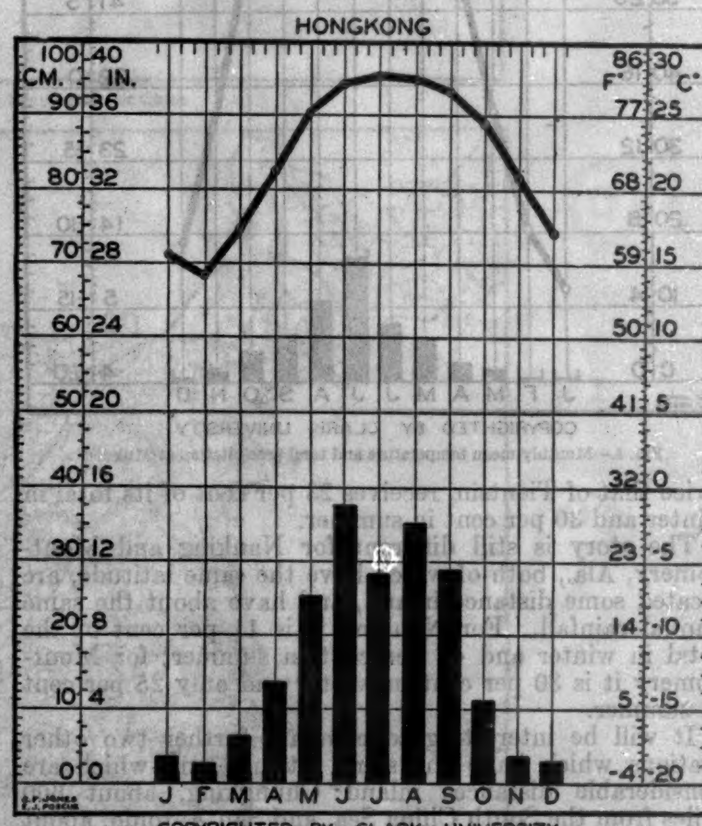

FIG. 4.—Monthly mean temperature and total precipitation at Hong Kong

out the nation the latter condition generally obtains in summer and the former in winter.

It can be readily seen from the accompanying maps of the mean annual rainfall, as well as from the graphs, that the rainfall (including some snow in the north) increases from north to south, and that it is much the heaviest during the three summer months. It may also be noted from the graphs that the three winter months in Mukden and Tientsin on the average are relatively dry, scarcely no rain or snow falling. These cities receive only 3 per cent and 2 per cent, respectively, of the total annual precipitation during the winter, while they receive 60 per cent and 72 per cent, respectively, during the three summer months. Compare these percentages with the similarly situated American cities: Albany receives 20 per cent of its total in winter and 30 per cent in summer; and Washington, with an annual precipitation of just

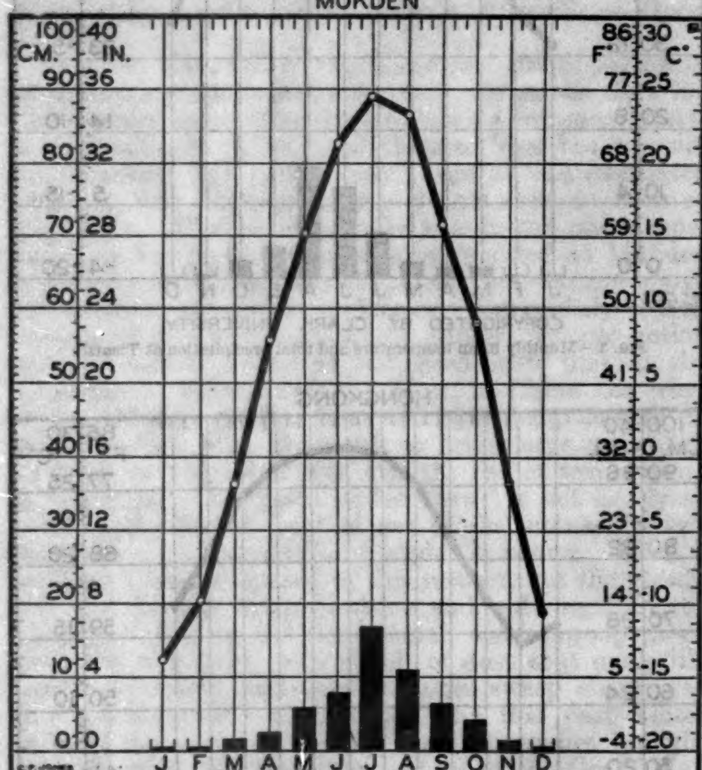

FIG. 5.—Monthly mean temperature and total precipitation at Mukden

twice that of Tientsin, receives 23 per cent of its total in winter and 30 per cent in summer.

The story is still different for Nanking and Montgomery, Ala., both of which have the same latitude, are located some distance inland, and have about the same annual rainfall. For Nanking it is 11 per cent of the total in winter and 48 per cent in summer; for Montgomery it is 30 per cent in winter and only 25 per cent in summer.

It will be interesting to compare further two other stations which have the same latitude and which are considerable distances inland: Chungking, about 600 miles from the South China Sea, and San Antonio, about 150 miles from the Gulf of Mexico, both have rather high plateau areas to the west. Chungking receives only 6 per cent of its total rainfall in winter, while San Antonio receives 17 per cent; for the three summer months the percentages are 41 and 25, respectively. Yet Chungking is reported to be perpetually cloudy, so much so that the dogs there bark when the sun appears. Even subtropical Hong Kong receives only 4 per cent of its nearly 90 inches of rain in winter, while its American counterpart, Havana, gets 14 per cent for the same period.

These figures are striking. Yet every station in China shows that the heaviest rainfall occurs in the summer half of the year, with pronounced maxima usually in June or July (and less frequently in September), and pronounced minima in December and January. Nanking is unusual in showing a secondary maximum in April. Chu attributes this to the increased number of cyclones moving out the Yangtze Valley at this time of year.

The big fact remains, however, that precipitation is heaviest in summer because then the winds are prevailingly from the southeast and are bringing in relatively large quantities of water vapor. As these winds are forced to ascend either by mountains or by the process of convection, heavy downpours are the result. In the winter, however, cold winds with little moisture are blowing out of the continental interior and are being made relatively drier as they are warmed in their descent from the highlands to the lowlands.

Chu, in discussing the normal conditions of rainfall in Nanking, states that the following description "applies equally well to Nanking and the whole Yangtze Valley," From the middle of June to the middle of July "the sky remains wholly overcast with clouds, and more or less rain falls every day. The air is so moist that walls and pavements become damp and furniture and clothes get moldy. The weather is indeed depressing and unpleasant." After the middle of July the weather is less rainy, and intervals of fine weather are frequent.

Probably even Nanking does not always experience such excessive dampness, records showing that the rainfall of this station is quite variable. For instance, in 1914 the total for June and July was less than 4 inches, or only 23 per cent of the normal for those two months. On the other hand, conditions must occasionally be even worse than Chu has indicated, for in 1915 nearly 24 inches of rain fell during these same two months; this was 160 per cent more than the normal.

In general this arrangement of summer rains and winter droughts is fortunate for China, because the rains come during the season when they are most needed for crops. Unfortunately, however, average conditions are far from dependable, as this case of Nanking would seem to indicate. In fact, it is quite rare when any considerable part of the Republic experiences an approximation of these average conditions. Either the rain comes too early or too late, or else too much comes in too short a period or fails altogether. It appears that some portion of the country annually suffers from droughts or floods ranging from inconsequential to very severe ones.

Droughts are most common in north China, less frequent in central China, and rarely occur in southern China. In the north the amount of rainfall under normal conditions is none too heavy; hence, even a slight diminution in the amount received during any period of the growing season causes hardship. For instance, in 1902 only 10 inches of rain fell at Tientsin; this is less than that received in most of our semiarid West. In 1920 this same station recorded only 11 inches; and it was during this year that most of northern China, an area of nearly 400,000 square miles and involving from 30 to 40 millions of people, received less than half of the average amount of rainfall. Many places in this region received

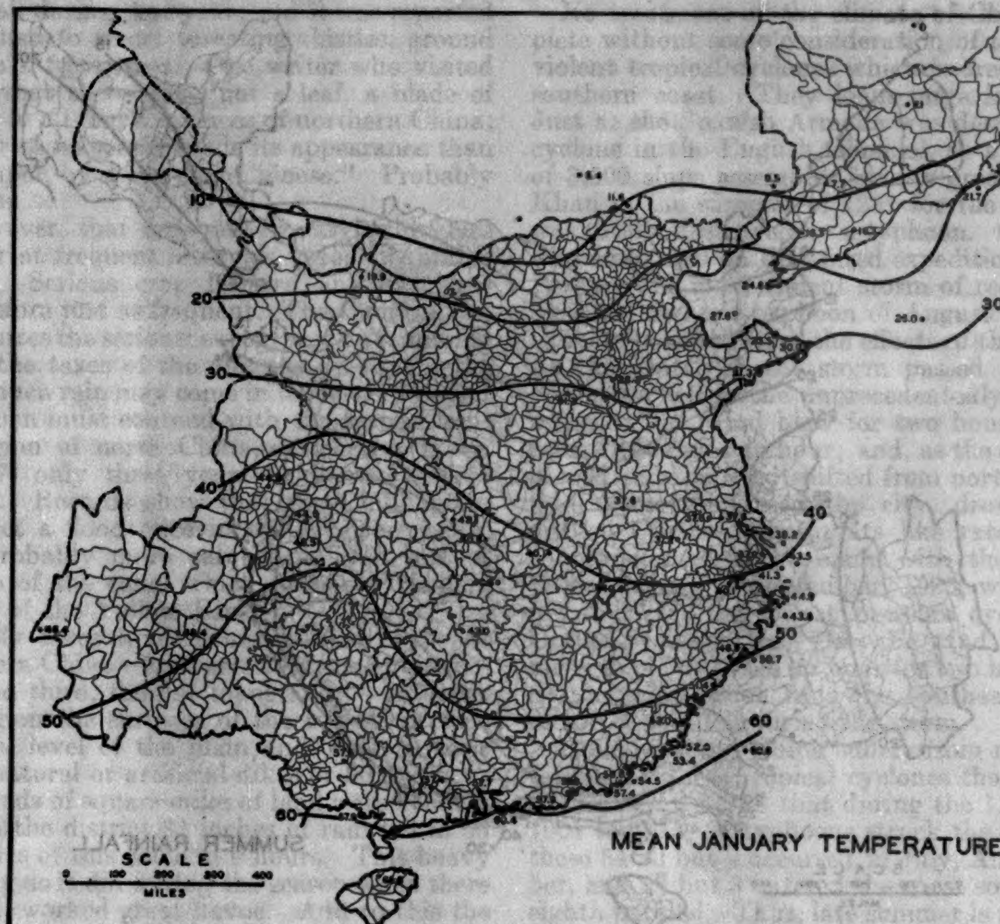

FIG. 6.—Mean January temperature for China

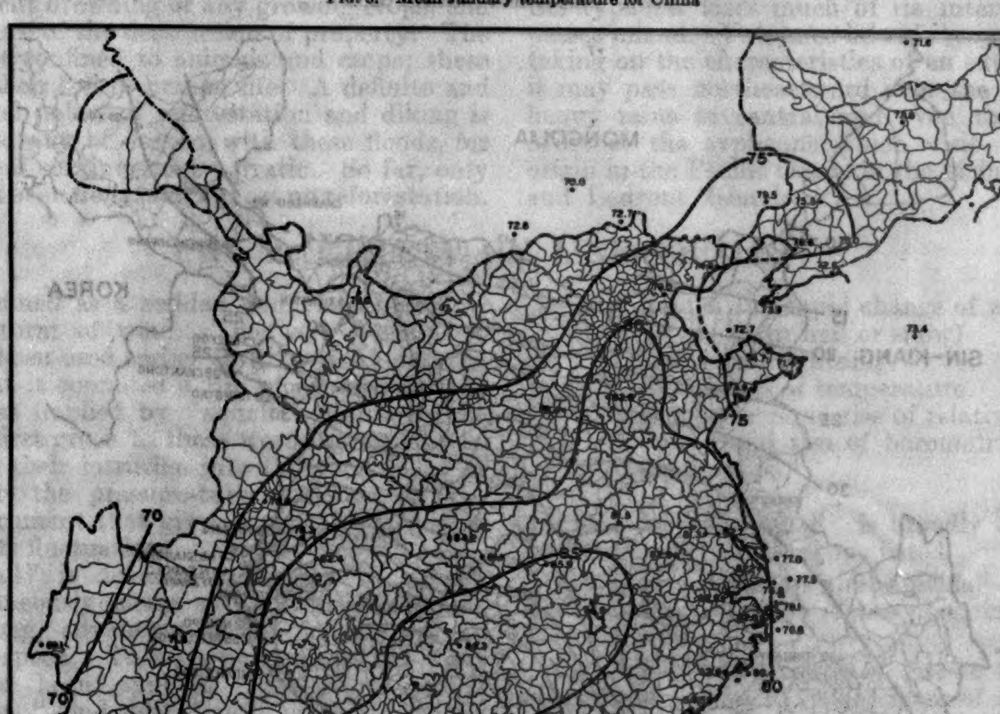

FIG. 7.—Mean July temperature for China

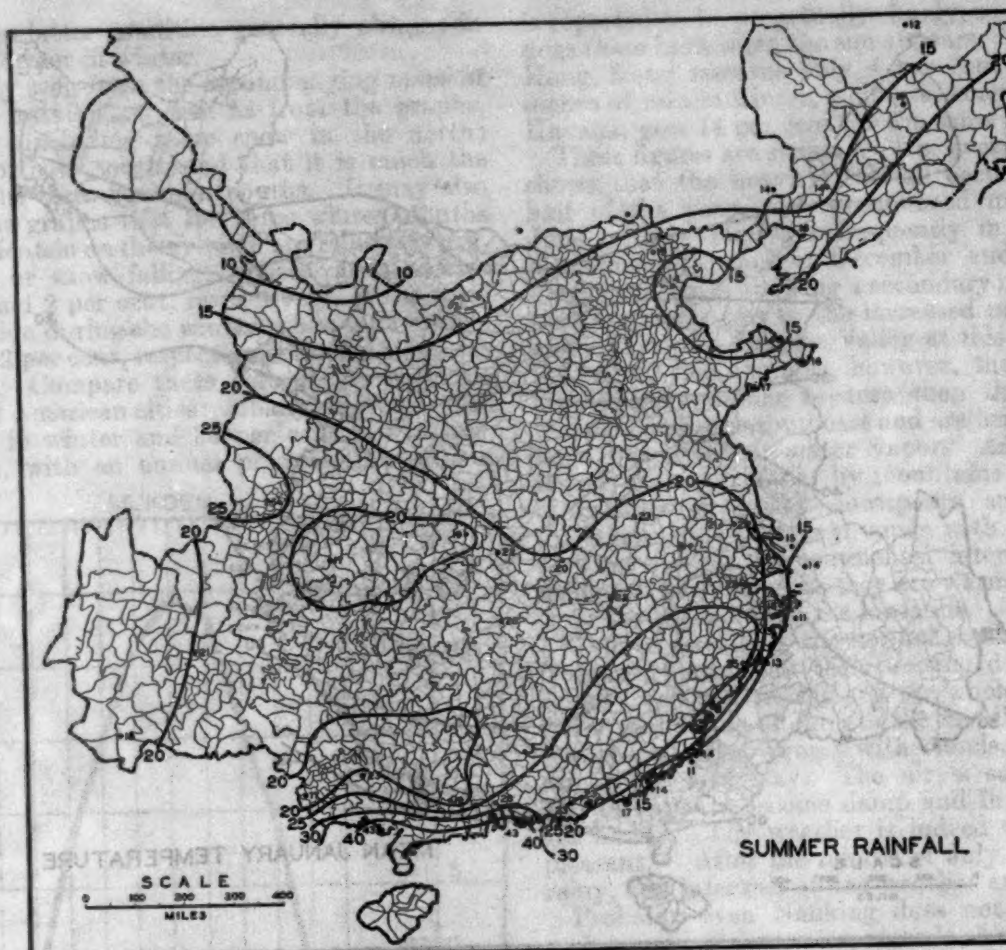

FIG. 8.—Mean summer rainfall for China

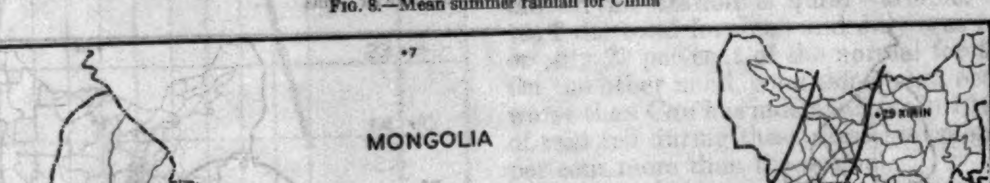

FIG. 9.—Mean annual rainfall for China

little or no rainfall during that year; and it was reported that the people had to resort to eating thistles, ground corncobs, and bark from trees. One writer who visited this region said that there was "not a leaf, a blade of grass, or a twig" in all four Provinces of northern China; for "a blade of grass no sooner made its appearance than it was pounced upon by a starving Chinese." Probably this is exaggerated.

It is true, however, that droughts of varying degrees of intensity occur at frequent intervals, especially in this northern sector. Serious crop failures and resulting famines are therefore just as frequent. The Government sometimes recognizes the seriousness of these by remitting all or a part of the taxes of the affected area. On the other hand, too much rain may come in too short a period and the people then must contend with floods. In fact, in this same region of north China, destructive floods occurred in 1917, only three years before the severe drought of 1920. Records show that the Chihli plain region may expect a flood once in six or seven years; this region is probably more subject to this sort of calamity because of the canal which connects Tientsin with a tributary of the Yellow River.

There are really three fundamental causes of floods here in northeastern China—first, erratic rainfall; second, deforestation; and third, the flat topography. In many places in this region the surfaces of the rivers are well above the general level of the plain and held in their courses only by natural or artificial dikes or levees.

In 1924 thousands of square miles of land were flooded. At one station in the district 23 inches of rain fell in 33 hours, and 9 inches of this came in 9 hours. This heavy downpour, coming as it did during the season when there was most rainfall, worked great havoc. Add to this the fact that water frequently remains on the land for months with the consequent drowning of any growing crops, and you have a measure of the destruction of property. The destruction is not confined to animals and crops; these floods also take their toll of human life. A definite and consistent national policy of reforestation and diking is the only adequate way of dealing with these floods, for rains will doubtless continue to be erratic. So far, only a little diking has been done, and almost no reforestation.

No treatment of the climate of China would be complete without some consideration of the typhoons, those violent tropical cyclones which so frequently ravage the southern coast. They loom large in Chinese history. Just as the Spanish Armada was destroyed by a violent cyclone in the English Channel, so a vast Chinese fleet of 3,500 ships assembled by the great Emperor Kublai Khan in the summer of 1281 for the invasion of Japan was totally destroyed by a typhoon. Of the 100,000 men who embarked on that fated expedition, only 3 returned. Perhaps the most violent storm of recent years was the so-called Swatow typhoon of August 1922, when 40,000 Chinese perished from the effects of the winds and water. As the center of the storm passed over the city the barometer fell to the unprecedentedly low level of 27.53 inches. The wind blew for two hours at an estimated rate of 100 miles an hour; and, as the center of the storm passed and the wind shifted from north to south, a great tidal wave inundated the city, drowning the closely packed Chinese inhabitants like rats. An interesting comparison might be made with the hurricane which visited Miami in September, 1926, when the barometer fell to 27.61, the lowest pressure ever recorded in the United States. Here, also, the wind blew at a speed of more than 100 miles an hour for two hours, first from the northeast and then from the southeast. From 8 to 16 inches of rain fell during the storm.

Unfortunately, China suffers from more frequent visitations by these tropical cyclones than does the United States. Chu found that during the 12-year period from 1904 to 1915, 54 typhoons struck the Chinese coast. Of these 54 all but 9 occurred in July, August, and September, and all but 3 entered the coast south of the twenty-eighth parallel. Thus, late summer is the most dangerous time, and southern China is the particular sufferer, for the typhoon loses much of its intensity as soon as it passes inland. Yet, once inland it may not die out; but, taking on the characteristics of an extratropical cylcone, it may pass northeastward over the interior and bring heavy rains to central and even to northern China. Most of the typhoons which visit China have their origin in the Pacific Ocean in the vicinity of the Caroline and Ladrone Islands.

M. A. GIBLETT ON LINE-SQUALLS [1]

"Squall" is defined as a sudden and violent gust, a blast or sharp storm of wind. The word "gust," it would seem, had been used earlier than "squall" and the implication is that it connoted a rise of wind of shorter duration than was implied by "squall." Some degree or precision was first given to these words as applied to wind when, after their intrusion into the vocabulary of the meteorologist, the pressure-tube anemometer was invented, an instrument that gives a continuous record of the wind and its fluctuations.

The "line-squall" is defined as a series of squalls occurring simultaneously along a line sometimes hundreds of miles long, advancing across the country at variable rates of speed. To such phenomena the word "line-squall" has been applied. The expression is synonymous with "wind-shift line" as used in the United States.

The characteristic manifestations of a line-squall on the ground are—

A sudden and rapid change of wind direction.
Heavy rain (or hail or snow).
Thunder and lightning.
A sunden fall of temperature.
A sudden or rapid rise of relative humidity.
A very rapid rise of barometric pressure during the passage.

The term "line-squall" is broadly applied to the ensemble of occurrences above listed.

The author considers the rapid fall of temperature as the basic characteristic of the phenomena and so treats the subject.

The fall of temperature is due to the arrival at the moment of a distinct colder mass of air which replaces the previously existing warmer current, and the line-squall is the physical result of this action. Accordingly, the basis of all that follows is the consideration of events when relatively cold masses of air impinge on relatively warmer ones. This brings into prominence the element temperature, which, at least from the point of view of airships, whether moored or in flight, is hardly second in importance to wind.

[1] Line-squalls, by M. A. Giblett, M. Sc. (Lond.). The Journal of the Royal Aeronautical Society, 198:509–549. June, 1927.

The author, who is superintendent airship meteorology division, Air Ministry, presents a very comprehensive discussion of line-squalls, from which the material here presented is abstracted.—*Editor.*

Line-squalls associated with barometric depressions of Temperate Zones.—In temperate regions, as is well known, the juxtaposition of relatively cold and warm air masses along lines of considerable length is found prinpally in association with the traveling low-pressure systems or barometric depressions of the middle latitudes; indeed, it is a fundamental feature of their structure.

The author uses as his illustrative material a typical distribution of barometric pressure over Europe and the northeast Atlantic Ocean during a disturbed period. It consists of a system of three depressions situated between anticyclones over the Mediterranean area and over the area southwest of Greenland. Analyzing this situation on modern lines, the author reveals a structure, the most important feature of which is shown on Figure 1.

Here the stippled area of the chart is that covered at the moment by air of direct, or rather, recent, polar origin, while the remainder of the chart is an area covered by relatively warmer air of recent tropical or subtropical origin. Arrows show the wind direction at about 1,500 feet at the time of the chart, the longer arrows indicating the stronger winds. It will be seen that the dividing

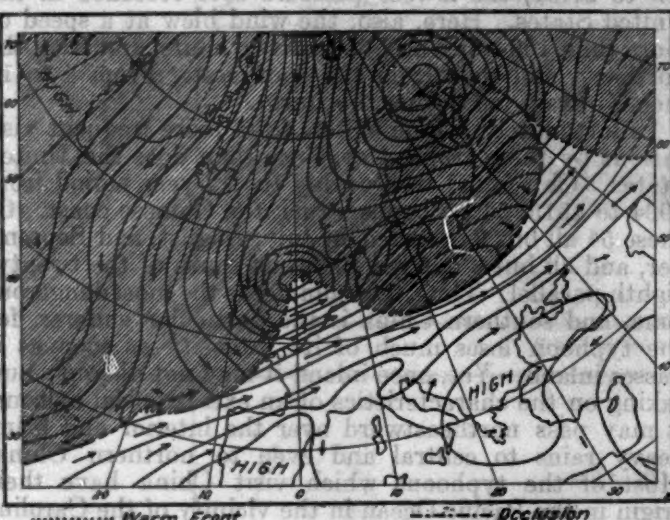

FIG. 1.—Illustrating the "polar front"

line along which the two air masses are in close contact is sinuous and that it is intimately connected with the depressions, forming a link between them which is not in any way apparent when Giblett's Figure 2 (not reproduced) alone is considered. This line has received the name "polar front" on the analogy of a battle front, because the warm and the cold air masses are in a state of conflict along it, the manifestation of this being the barometric depressions and associated air motion.

It is pointed out in the discussion of Figure 1 that the "polar front" is divided up into segments according to the key at the bottom of the figure. The middle one of the three depressions is seen to have a sector of warm air extending to its center. There is a law that the center moves in a direction parallel to the isobars of this warm sector, as shown in the figure by an arrow. During this displacement the forward boundary of the warm sector moves into the space at present occupied by cold air; in other words, along this segment of the polar front warm air is replacing cold, and the segment is called a "warm front." On the contrary, along the segment bounding the warm sector in the rear, cold air replaces warm, and this segment is called a "cold front."

The air of the warm sector, in addition to replacing the cold air at the ground along the warm front, actually gains on it and rises over it. The cold air which replaces the warm air at the ground along the cold front also gains on it and undercuts it. The result is that as time passes the cold front gains on the warm front and ultimately overtakes it. The combined cold and warm front is called an "occlusion," and an example is seen in the northernmost depression of Figure 1. The cold air in the rear of the occlusion is not necessarily at the same temperature as that in front, having had a different history; it is more frequently colder, in which case the occlusion retains some characteristics of the cold front, for we still have cold air replacing relatively warmer air.

The stage of occlusion is one of the later phases in the life history of depressions, and it has been reached in by far the greater number of depressions in the vicinity of the British Isles. The southern depression of Figure 1 has only recently formed, and its warm sector is as yet only a small wave in the polar front.

In addition to the segments of the polar front thus far described there are portions joining the cold front of one depression to the warm front of the next. These portions are temporarily stationary, neither warm nor cold air gaining along them. Further, "secondary cold fronts" may occur in the body of the polar air, as illustrated by the example attached to the northern depression in Figure 1. Here the polar air to the east is being replaced by yet colder polar air of somewhat different recent history.

The portions of the polar front in which primary interest is centered, as being those where line-squall phenomena manifest themselves, are the cold fronts, or segments where the polar air is gaining ground. Similar phenomena may be exhibited along occlusions and secondary cold fronts, but warm fronts are of a totally different character, and their detailed consideration is outside the scope of this paper. Cold fronts have also received the name "squall-line"; and in America "windshift line," what is often called the "trough" of a barometric depression, also coincides with the cold front.

The author believes the most logical view is to consider all cold fronts as line-squalls in the broader sense of a previous paragraph but to realize that the associated phenomena may be present with very different intensities in different cases. In what follows when the word "front" is used without qualification a cold front (or secondary cold front or occlusion) will be implied, but not a warm front.

MOTION OF LINE-SQUALLS; DIRECTION; SPEED; RELATION TO BAROMETRIC DEPRESSION

Certain definite questions about line-squalls may now be answered.

Figure 2 reproduces the polar front of Figure 1. The letters A, B, C, D, E, F, G, H, J, K, and M serve to indicate the position of the front at certain times; and the same letters with an accent, thus, A′, B′, C′, D′, etc., show the position six hours later; thus the depression centered at C having reached C′, that at F having reached F′, and that at K having moved very little to K′, slow movement being a characteristic of a depression when the occluded stage has been reached.

The idea once prevalent that line-squalls radiate from the centers of depressions like the spokes of a wheel is disposed of as follows: This is certainly approximately true of the cold front of a relatively young depression, such as that centered at F, but the cold front HJ does

not bear such a relation to the occluded depression centered at K. Even if notice be taken of the occlusion JH, the whole HJK would form a very crooked spoke of a wheel with axis at K.

The question is asked, Is the advance of a squall line uniform along its whole length? And answered very definitely in the negative.

Figure 2 shows that in the case of the depression F the cold front near F has advanced almost across the North Sea in six hours, about 50 miles per hour, whereas the

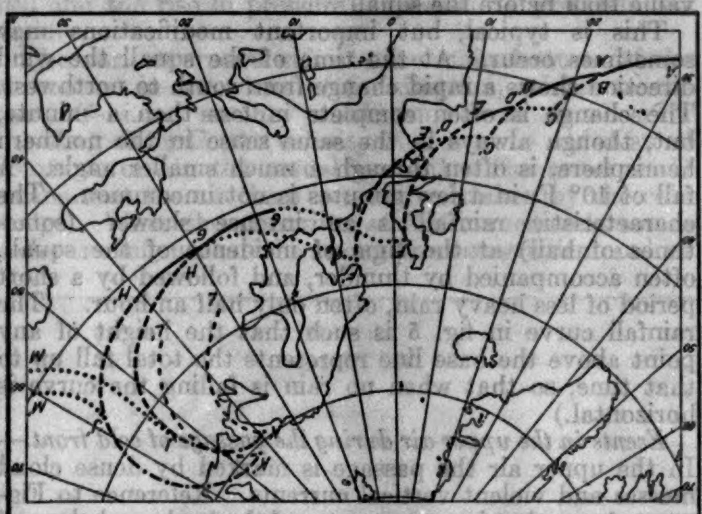

FIG. 2.—Illustrating the displacement of the "polar front"

portion near Brest, having moved very little to D′E′, is then temporarily stationary prior to receding as the warm front C′D′ of the next depression. A rate of advance greater than 60 miles per hour may occur but is not common; rates of 30 miles per hour or more are quite common.

The question, Is there any relation between the rate of advance of a line-squall and that of the depression with which it is associated? is asked, and answered by the statement that there is no simple relation. There is, however, one simple relationship of practical value when using weather charts, and that is that in active systems the rate of advance of any section of a cold front is approximately equal to the component perpendicular to the front of the gradient wind in the polar air in its rear (the gradient wind being the theoretical wind at 1,500 feet as readily measured from isobars on the chart).

The direction of motion of line-squalls is said to be normally from somewhere between northwest and southwest or south to north. There is very rarely a component from the east in the motion.

line-squalls, including all degrees of intensity, is high, but for every severe one there are many of only moderate or slight intensity. Line-squalls may recur at any place at short intervals during some periods, and then there may be a period of even weeks free from them.

The horizontal length of a line-squall in a characteristic case is well represented by those of the cold fronts in Figure 2, i. e., anything up to a thousand miles. And we have already seen that there is a considerable variation of speed of advance along the front.

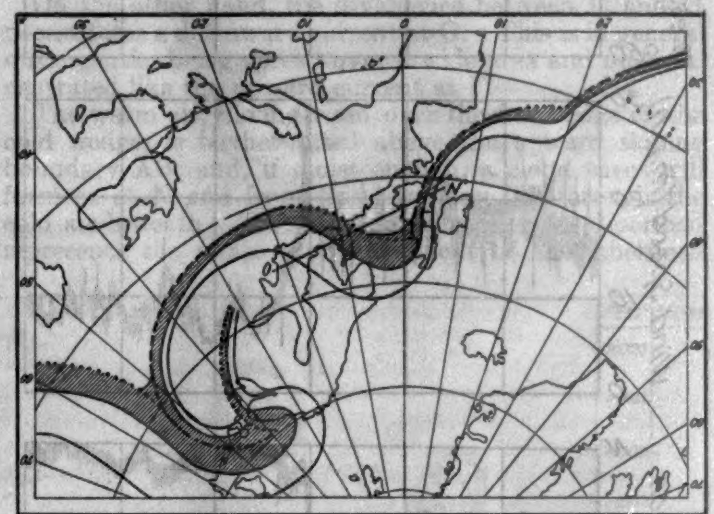

FIG. 3.—Illustrating the association of rain and cloud with the "polar front"

The length of life of a line-squall is often at least 24 hours, but in this connection is is necessary to consider its transition. The length of life may be very different for various portions of the same front. In Figure 2 the northern portion of the cold front EF will ultimately overhaul the warm front FG and form an occlusion. It may be many hours before this is achieved, and even afterwards the occlusion may have the character of a cold front and persist for a further considerable period before dying out. The southern portion of EF is, on the contrary, slowing down, shortly to become stationary at D′ E′ and then to become in turn a portion of the warm front C′ D′ of the next depression. The length of life of the polar front of Figure 2, considered as a whole, is much longer than the period during which any one portion of it retains a particular form, as old depressions die and new ones form in association with it, until ultimately the polar air has spread over the whole area at present occupied by the warm air, or until the polar air has become warmed to such an extent that the

FIG. 4.—Section along N—O of Figure 3

FREQUENCY OF OCCURRENCE OF LINE-SQUALLS; HORIZONTAL LENGTH; LENGTH OF LIFE

Since there are cold fronts associated with all active depressions of temperate latitudes the frequency of

contrast of temperature disappears. This marks the end of that particular spell of disturbed weather.

Figure 3 is another presentation of the polar front of Figure 1 in which the stippled area represents, necessarily in a somewhat idealized way, the associated rain

area. Any rain falling elsewhere would be purely local. The continuous line outside the rain area represents the outer edge of the cloud system responsible for the rain.

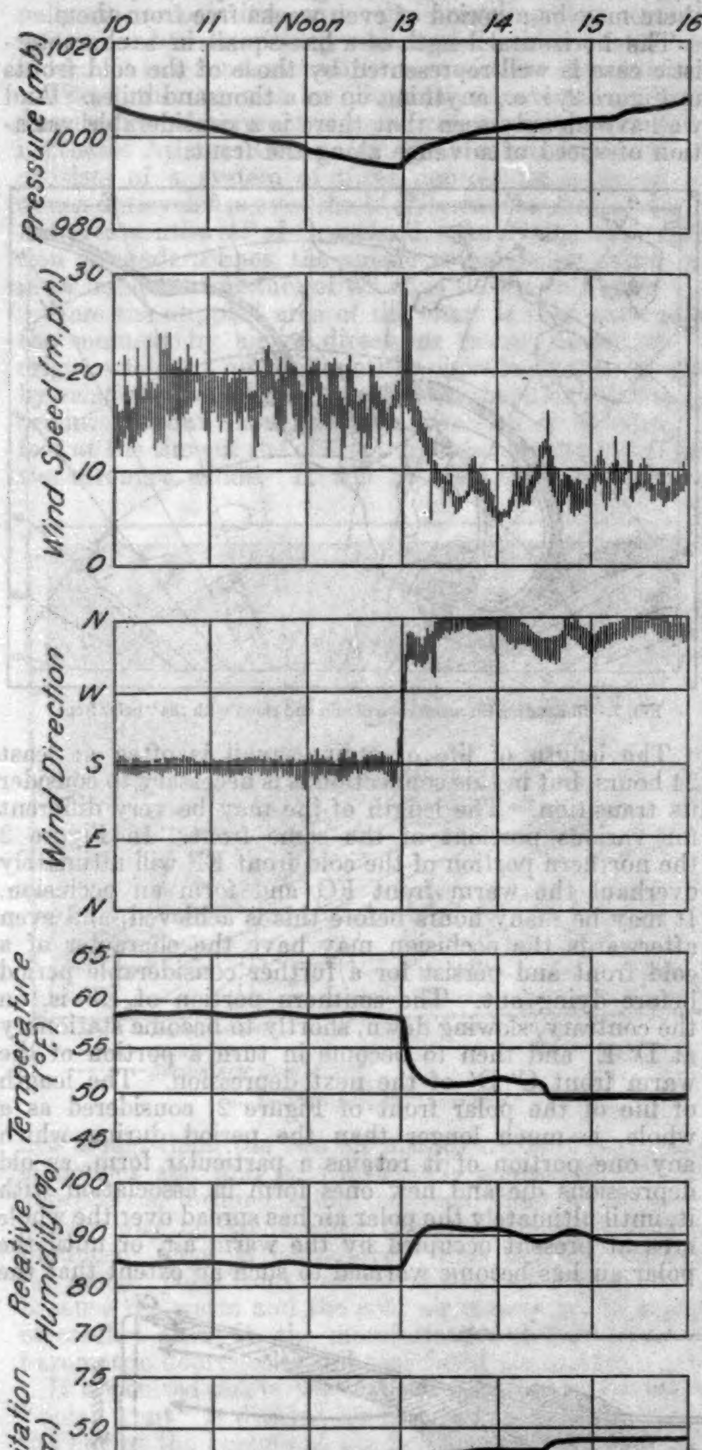

FIG. 5.—Changes during the passage of a typical cold front

Figure 4 shows the vertical sections along the line N—O of Figure 3 and gives a generalized view of conditions in the upper air. This diagram should be read in connection with Figure 3.

Events at a ground station during the passage of a cold front.—In general the sequence of changes in the several weather elements are shown in Figure 5 and little comment is necessary.

The barometric pressure which has been falling steadily shows a rapid rise at the time of incidence of the cold front, followed by a more gradual rise. The magnitude of the rapid rise is often several millibars in a few minutes. The wind speed shows a sudden increase of short duration, followed by a decline to a less value than before the squall.

This is typical, but important modifications may sometimes occur. At the time of the squall the wind direction shows a rapid change from south to northwest. The change is often complete in less than a minute, but, though always in the same sense in the northern hemisphere, is often through a much smaller angle. A fall of 10° F. in a few minutes is not uncommon. The characteristic rainfall is an intense shower (sometimes of hail) at the time of incidence of the squall, often accompanied by thunder, and followed by a short period of less heavy rain, often only half an hour. (The rainfall curve in fig. 5 is such that the height of any point above the base line represents the total fall up to that time, so that when no rain is falling the curve is horizontal.)

Events in the upper air during the passage of cold front.—In the upper air the passage is marked by dense cloud masses and violent vertical currents. Reference to Figure 4 shows that in consequence of the backward slope of the boundary between warm and cold air (the whole system being supposed moving from left to right) the arrival of the cold air, and with it the shift of the wind, is delayed the more the higher the level considered. The first 1,000 feet or so are, however, excepted for reasons to be explained. The total fall of temperature at, say, 10,000 feet is often much greater than at the surface. Soundings by airplane in the British Isles, before and after the passage of cold frosts, have shown falls of 20° F., when those at the surface have been only a few degrees. The precise rate of fall and rapidity of wind shift at higher levels have not been directly measured, but they probably do not often take place in such a very short time as at the surface.

DETAILED STRUCTURE OF LINE-SQUALL

Considering now in much more detail conditions a few miles on either side of the line-squall, or forward edge of the cold air in the cold front of Figure 4, the horizontal distance is only just distinguishable on the scale of that diagram. Owing to the difficulty of observing, no complete survey of any one case at all heights has ever been made, but there are many fragmentary observations available of various phases of different cases. Piecing these together and combining with them personal observations and certain theoretical considerations, the author arrives at a picture of the essential features in the immediate neighborhood of the line-squall, and this is shown in Figure 6.

In this diagram the horizontal and vertical scales are the same, so that a correct idea of the proportions is at once given. The shaded area is a section through the tip of the cold wedge which is supposed to be advancing to the right.

Owing to surface friction the cold air is found farther advanced some distance above the surface than at the ground itself, and the upper limit of the cold air AB,

instead of continuing on until it cuts the ground, is doubled back and meets it at the point C. This point is to be considered as marking the cold front at the ground. The rate of advance of this point to the right in the diagram, or in other words the speed of the cold air at C in this direction, is the rate of advance of the front. In a typical case, the passage of the whole portion of the cold wedge shown in this diagram would only be a matter of 10 minutes or so. Beyond the left of the diagram the upper boundary of the cold air slopes at a smaller angle still and the rise in pressure consequently proceeds less rapidly.

The various arrows indicate the main features of the air motion in the plane of the diagram, *relative* to the point C—i. e., as they would appear to an observer traveling along C (the velocity of C is to be added at all points to obtain the actual motion). The arrow at D means that the air there is being overtaken by the cold wedge. When the air arrives at E it immediately comes under the influence of the strong pressure gradient and its passage of C, when a decrease of wind takes place. The arrow at H indicates that the air there is losing on the front C.

As regards vertical motion, the strong horizontal convergence between D and E necessitates a strong upward current at F. If there is sufficient water vapor present, cloud will form here; and owing to the tendency of the cold air at B to fall, a rolling motion, as indicated, may be imparted to this cloud, which is the characteristic long roll cloud of a line-squall seen in cross section.

On the other hand, the divergence between C and H necessitates a downward current at G. This is in general quite gentle, being spread over a wide area and not concentrated like the upward current at F.

The warm air, having risen over the front edge of the cold wedge, is farther lifted above the upward sloping boundary AB; and, if moist enough, a cloud sheet will form as at N and from this rain may fall through the cold air beneath. The whole system as so far described represents the phase of development of the Aberdeen

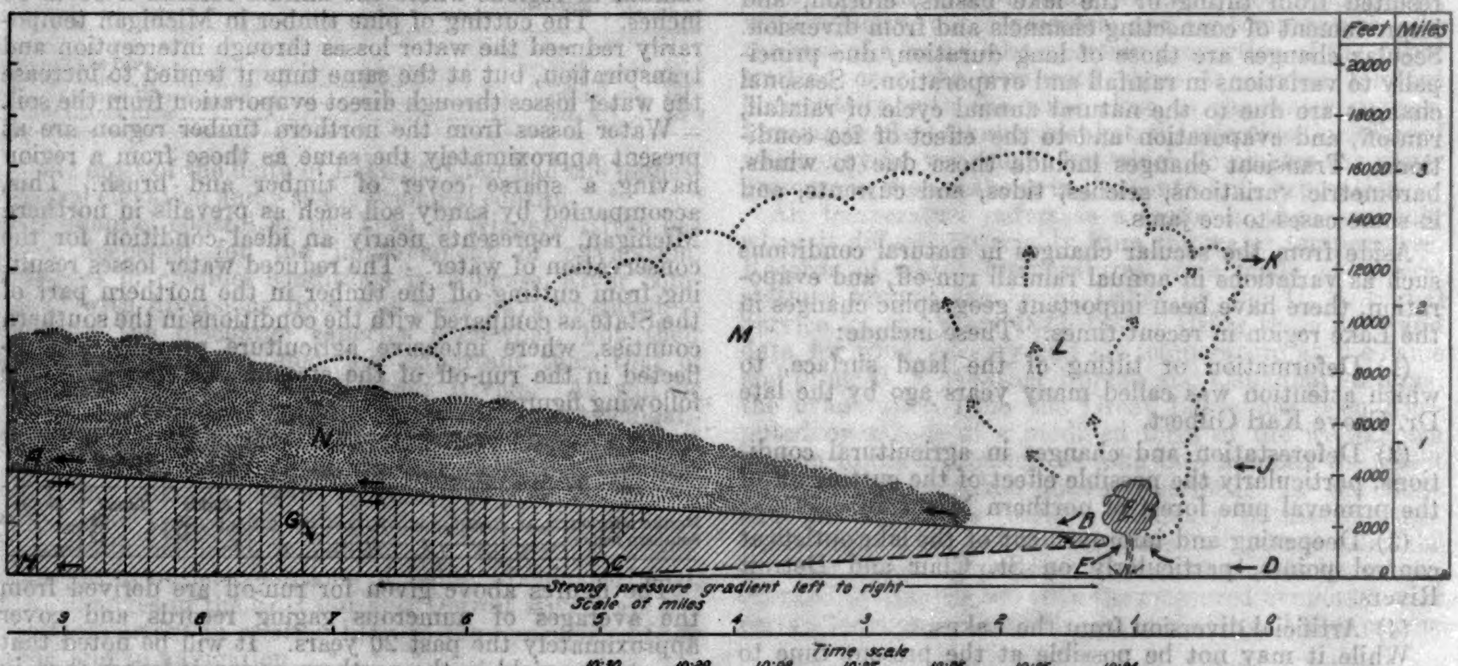

FIG. 6.—Detailed structure of line-squall

relative motion is checked or even reversed. It is therefore on the passage of this point that the first sudden change of wind takes place at a ground station.

The squall as measured on an anemogram may be said to have commenced. It continues until a little after the line-squall of October 14, 1912, of which a detailed description accompanied by cloud sketches has been given by Mr. A. G. Clark in his book on "Clouds."—*A. J. H.*

HORTON AND GRUNSKY ON THE HYDROLOGY OF THE GREAT LAKES [1]

Abstracted by ALFRED J. HENRY

This volume of 432 octavo pages is replete with hydrologic and related data bearing upon the rise and the fall of the level of the Great Lakes due to natural causes or as the authors put it—the cycle rainfall, run-off, and evaporation. This cycle as related to the Great Lakes invloves the following-named elements:

(1) Rainfall on the drainage basins tributary to the Lakes.
(2) Rainfall on the lake surfaces.
(3) Evaporation from the lake surfaces.
(4) Run-off and inflow into the Lakes.
(5) Outflow from the Lakes.
(6) Lake levels and their fluctuations.

Measurements.—More or less isolated measurements of outflow were made from time to time but it was not until about 1896 that systematic measurements were undertaken by the U. S. Lake Survey. Complete records of lake levels extend back to 1860, and approximate levels can be carried back to 1835. Records of precipitation

[1] Report of the Engineering Board of Review of the Sanitary District of Chicago on the Lowering Controversy and a Program of Remedial Measures, Part III, Appendix II, by Robert E. Horton, in collaboration with C. E. Grunsky, 1927.

from about 1870 onward are available for a number of stations in both Canadian and United States territory within the drainage basin of the Great Lakes.[2]

In general, it has not been possible heretofore to obtain a satisfactory correlation of stage and discharge relations of the Great Lakes with the controlling factors rainfall, run-off, and evaporation for lack of the essential basic data, particularly records of run-off from tributary streams.

Changes or variations in lake level are due to a variety of causes, which may be classed as natural or artificial. Variations due to natural causes include those resulting from variations in rainfall and evaporation, those due to ice conditions and erosion, and transient variations due to barometric changes, wind action, seiches, currents, tides, and waves. Artificial changes include those resulting from channel improvement, control works, and diversion. Variations in lake level may also be conveniently classed as (*a*) permanent, (*b*) secular, (*c*) seasonal, and (*d*) transient. Permanent changes may have resulted from tilting of the lake basins, erosion, and improvement of connecting channels and from diversion. Secular changes are those of long duration, due principally to variations in rainfall and evaporation. Seasonal changes are due to the natural annual cycle of rainfall, run-off, and evaporation and to the effect of ice conditions. Transient changes include those due to winds, barometric variations, seiches, tides, and currents, and in some cases to ice jams.

Aside from the secular changes in natural conditions such as variations in annual rainfall run-off, and evaporation, there have been important geographic changes in the Lake region in recent times. These include:

(1) Deformation or tilting of the land surface, to which attention was called many years ago by the late Dr. Grove Karl Gilbert.

(2) Deforestation and changes in agricultural conditions, particularly the possible effect of the cutting off of the primeval pine forest of northern Michigan.

(3) Deepening and improvement of the lake outlets at control points, particularly on St. Clair and Detroit Rivers.

(4) Artificial diversion from the Lakes.

While it may not be possible at the present time to determine with precision the effects of tilting and deforestation in relation to the hydrology of the Lakes, yet a discussion of these subjects may serve to clarify the situation by showing at least the relative importance or lack of importance of these factors as compared with other factors affecting lake levels and outflow.

Tilting of land surface.—A general tilting of the land surface in the Lake region began in the glacial period and was apparently most rapid immediately following the withdrawal of the ice sheet and continues in some degree at present. It seems probable that at present the deformation of the surface is in the nature of an uplift to the north of a hinge passing near Port Huron and crossing the Lake region in a direction a little north of west. The actual elevation of the outlet of Lake Michigan-Huron relative to sea-level datum is apparently changing but little, if any, at present. * * * Apparently it may be safely concluded that changes in the hydrology of the Great Lakes due to land movement are of little present importance if not wholly negligible, however important they may be locally at certain places around the Lakes.

[2] Cf. Day, P. C. Precipitation in the drainage area of the Great Lakes, 1875–1924, MONTHLY WEATHER REVIEW, March, 1926, 54; 85–106.

Deforestation.—Profound changes in the vegetal cover of the region tributary to the Great Lakes have taken place since 1860, the date when systematic lake-level observations began. These changes have included:

1. Cutting off of the primeval pine forest of northern Michigan and in a large measure the hardwood forests also.

2. Increase in the extent of land under cultivation in the region originally forested in the northern part of the State and a smaller increase in land under cultivation in the southern part of the State. * * * Water losses from regions covered with vegetation are of three kinds:

(1) Interception of rainfall by the leaves and stems of trees or plants and its direct evaporation before reaching the ground.

(2) Transpiration by plants, particularly through the stometal openings of their leaves.

(3) Direct evaporation from the soil.

Interception by well-stocked, mature pine forests is relatively large, amounting to about 25 per cent of the rainfall in regions where the annual rainfall is 30 to 35 inches. The cutting of pine timber in Michigan temporarily reduced the water losses through interception and transpiration, but at the same time it tended to increase the water losses through direct evaporation from the soil.

Water losses from the northern timber region are at present approximately the same as those from a region having a sparse cover of timber and brush. This, accompanied by sandy soil such as prevails in northern Michigan, represents nearly an ideal condition for the conservation of water. The reduced water losses resulting from cutting off the timber in the northern part of the State as compared with the conditions in the southern counties, where intensive agriculture prevails, are reflected in the run-off of the streams, as shown by the following figures:

	Precipitation	Run-off	Water losses
	Inches	*Inches*	*Inches*
Northern region	30	15	15
Southern region	34	12	22

The figures above given for run-off are derived from the averages of numerous gaging records and cover approximately the past 20 years. It will be noted that the stream yield in the northern region is larger than in the southern region, although the rainfall is less.[3]

The excess of water losses for the southern region at present amounts to 7 inches depth on the land surface. Since run-off equals rainfall less water losses, if the rainfall remains the same, the run-off must have been increased to some extent between 1860 and 1895 in the northern region, and it is now probably slowly decreasing as the extent of agriculture increases.

Changes in lake outlets.—For a lake of a given area the lake levels are controlled jointly by—

1. Inflow and inflow fluctuations.
2. The outlet channel capacity at control points.

[3] Grunsky holds that this difference is mainly due to the lower temperature and resulting lower evaporation of the more northerly region, particularly in the summer months, which allows more water to appear there as run-off for the same amount of rain than farther south where summer temperature is higher and evaporation greater. From a study of water losses from drainage basins in eastern United States it appears that the normal decrease of water losses proceeding northward is of the order of 1 to 2 inches per degree of latitude. The center of the northern region in lower Michigan, above considered, is located about 1° north from the center of the southern region. It would appear, therefore, that as regards the variation of water losses with latitude and consequently with temperature and evaporation, the difference between the northern and southern regions of Michigan, other things equal, should be about 2 inches. Instead, the actual difference is 7 inches. It does not appear possible to account for more than about one-half of the observed difference on the basis of differences in rainfall and evaporation combined. There is also evidence of watershed leakage from the north to the south region, which would tend to make the measured yield of the south region greater than the water production of the area.

Owing to backwater effects the controlling factors for Lakes Michigan-Huron operate in a somewhat complicated manner. Beginning at Niagara River the elevation of Lake Erie is controlled by shoals at the head of that river and to a less extent by the crest of the rapids at Niagara Falls. Lake Erie reacts through backwater on the lower Detroit River control in the vicinity of Limekiln Crossing. This in turn operates through backwater on Lake St. Clair. The level of Lake Huron is also controlled jointly by the topography of St. Clair River and by the level of Lake St. Clair.

Under natural conditions before any channel improvements were made there were five principal points of control of the outflow of Lakes Michigan-Huron. The natural bottom elevation at the points of control and the present approximate elevations of the improved navigation channels in feet and tenths above M. S. L. are as follows:

	Natural bottom elevation	Approximate present bottom elevation
	Feet	*Feet*
Foot of Lake Huron	563.0	557.6
St. Clair Delta	571.5	552.8
Head of Detroit River	559.5	552.8
Foot of Detroit River	560.0±	549.8

The crest of the delta of Lake St. Clair had the highest natural elevation and was the principal control. * * * The channel control at the head of Niagara River has been deepened for the improvement of navigation. Changes in channel conditions in Niagara River combined with diversions from this river have operated to increase the discharge capacity somewhat, but their effect is apparently much less important than that of changes in St. Clair and Detroit Rivers. As will be shown, the increased outlet capacity of Lakes Michigan-Huron has drained these lakes into Lake Erie to such an extent as to partly offset the effects of other causes operating to lower Lake Erie levels.

Overflow from Lake Superior has been in recent years completely subject to control by regulating works. Changes in outlet conditions of Lakes Michigan-Huron, i. e., changes in the St. Clair and Detroit Rivers are the most important in relation both to the hydrology of the lakes and to navigation. * * *

In the case of Lakes Michigan-Huron, changes in outlet conditions react slowly on lake levels, which require more than five years for full readjustment. Changes in the outlet of these lakes have long been in progress and the effects of different improvements overlap, so that the final resultant effect on the levels of Lakes Michigan-Huron has not yet been fully realized. Channel changes, diversions and effects of cyclical changes due to natural causes, have been going on together for many years. This makes it difficult to determine separately the effect on lake levels produced by different causes. Various estimates of the effect of channel improvement on the levels of Lakes Michigan-Huron have been made, ranging from 2½ to 8 inches or more. That the actual lowering of the levels of these lakes through uncompensated outlet channel deepening has been at least 8 inches seems now beyond doubt.

Rainfall.—Rainfall data for the Great Lakes region are relatively numerous and complete. * * * Using the rainfall records for Beaver Island in Lake Michigan and the small islands in the Straits of Mackinac as a basis for estimating the relation between rainfall on lake surfaces and that at adjacent land stations, the rainfall on the lake surfaces has been estimated separately from that on the tributary land surfaces, and further the division of the rainfall between winter and summer is shown in the table below:

	Lake Superior	Lake Michigan-Huron	Lakes Erie-St. Clair
On land areas:	*Inches*	*Inches*	*Inches*
November-April	10.12	15.67	16.72
May-October	18.53	18.81	18.33
Total	28.65	34.48	35.05
On water surface:			
November-April	11.44	14.16	14.56
May-October	16.95	17.16	16.33
Total	28.39	31.32	30.89

These figures differ slightly from those of Grunsky owing mainly to correction for snow deficiency and to separation of the rainfall on the lake and the land surfaces.

Evaporation.—In general, the evaporation losses from a water surface depends on several factors, including, in order of their importance, water surface temperature, wind velocity, vapor pressure, and air temperature. In the case of a broad lake a certain proportion of the vapor emitted near the windward shore is carried forward horizontally with the wind close to the water surface, forming in effect a vapor blanket, the effective thickness of which may be very slight but which dominates the vapor pressure in the air above in the control of evaporation.

Air temperature enters as a factor in this case only when it differs appreciably from the water temperature. Records of water temperatures were made at several stations around the Great Lakes by the U. S. Signal Service for the years 1873–1886. Using these data and data for wind velocity and air temperature at the same and other U. S. Weather Bureau and Canadian stations, the evaporation from the Great Lakes has been computed by means of a modified form of the well-known Dalton formula adapted to take into account the effect of the vapor blanket above described. In the table next below will be found a summary of the meteorological data used and the calculated evaporation for the different lakes. The result of the calculation have been checked by comparison with the measured evaporation at certain locations in and adjacent to the Great Lakes region.

Means of meteorological data and evaporation (1874–1875 to 1923–1924)

	Air temperature	Water surface temperature	Wind velocity	Evaporation
Lake Superior:	°F.	°F.	m. p. h.	*Inches*
November-April	19.6	[1] 26.8	5.2	4.23
May-October	54.1	49.2	4.8	11.23
Water year	36.8	38.0	5.0	15.76
Lakes Michigan-Huron:				
November-April	27.6	30.3	5.5	7.22
May-October	58.9	59.1	4.7	22.31
Water year	43.2	44.7	5.1	29.53
Lakes Erie-St. Clair:				
November-April	32.7	33.0	5.2	8.30
May-October	62.1	60.8	4.3	20.90
Water year	47.4	46.9	4.7	29.20

[1] Allowance for ice around lake margins.

Inflow to the Great Lakes.—Records of run-off are available covering 52.1 per cent of the land area tributary to Lakes Michigan-Huron and 36.2 per cent of the area tributary to Lakes Erie-St. Clair. The longer records extend back to 1902–03 or earlier but the records are more numerous and complete for the last 10 years.

The measured streams are generally well distributed over the area tributary to Lakes Michigan-Huron except the east Huron drainage for which records are meager. The available gauging records have been used as a basis of estimating the land surface inflow to Lakes Michigan-Huron and Erie-St. Clair by dividing the drainage basins into subareas each containing at least one long gauging record and applying the measured run-off determined from records in the subareas to the entire subarea. * * * Estimates of run-off for winter and summer have been made and used when necessary. Owing to the complicated hydrologic conditions in the Michigan-Huron Basin the estimated summer run-off is less than actual run-off [4] and that for winter exceeds the actual run-off by about an equal amount. Difficulty in estimating the seasonal run-off from the Michigan-Huron drainage basin results mainly from ground-water conditions. A large part of the summer run-off is derived from ground water stored during winter. * * *

Estimated run-off from land areas tributary to Lakes Michigan-Huron and Erie-St. Clair

Period	Michigan-Huron	Erie-St. Clair
Winter, inches from land area	5.38	8.98
Summer, inches from land area	9.15	3.16
Year, inches from land area	14.53	12.14
Year, cubic feet per second per square mile	1.07	0.90
Year, cubic feet per second	90,121	27,121

Outflow from the Great Lakes.—Lake Huron outflow can not be directly determined prior to about 1900, owing to the varying effect of changes in channel conditions. The mean outflow from the different lakes and for different periods is given in table next following. The figures for St. Clair and Niagara Rivers have not been corrected for Chicago diversion, beginning in 1900, which should be added to obtain the total outflow from the lakes. Where necessary all the records have been corrected for ice obstruction in winter season. The figures given for Niagara River are corrected for diversions into Welland and Erie Canals and for minor power diversions at the International Bridge at Buffalo, N. Y. The discharge of St. Clair River as determined from United States Lake Survey gaugings for the period 1905–1923 is 4 per cent greater than the discharge determined from Niagara gaugings corrected for Lake Erie storage and yield. While the flow estimated from gaugings is probably more accurate for summer, it is subject to more uncertainty in winter due to ice obstruction.

Summary of lake outflow data (not including the discharge of Chicago sanitary canal)

Period	Years	Winter	Summer	Year
		c. f. s.	*c. f. s.*	*c. f. s.*
St. Marys River, 1905–1923	19	65,200	71,600	68,400
St. Clair River,[1] 1905–1923	19	166,700	194,600	180,700
St. Clair River,[2] 1905–1923	19	152,900	193,700	173,500
Niagara River, 1905–1923	19	192,700	210,200	201,500
St. Marys River, 1860–1923	64	71,700	83,500	77,500
Niagara River, 1860–1923	64	199,100	216,500	207,800

[1] U. S. Lake Survey method based on 1912 discharge table.
[2] Niagara method.

CAUSES OF PRESENT LOW LAKE LEVELS

In January, 1925, Lakes Michigan-Huron were more than 4 feet below their levels of 1885. However, as 1885 was near the end of a cycle of wet years, a subsequent drop in levels was to be expected. With the data of inflow and outflow now available it is possible to determine separately the extent to which each of the several causes has contributed to the present low levels.

[4] As determined from measured lake outflow.

The authors consider the effect of channel improvement in St. Clair and Detroit Rivers and use three methods to determine the extent to which levels of Lakes Michigan-Huron have been lowered as a result of deepening and improving St. Clair and Detroit Rivers and have deduced from the three methods the fact that the elevation of Lake Huron has been depressed as a result of channel improvement to the extent of at least 8 to 10 inches.

The Chicago and other diversions have lowered the level of these lakes an additional 6 to 8 inches, thus making a total lowering of 14 to 18 inches. There remain, however, 30 to 34 inches to be accounted for. The depression due to a deficiency in precipitation is next considered, and it is found that 15½ inches may be attributed to reduced water production of the Lake Superior drainage basin. Using the figures that they have hereinbefore derived, it is shown that the water production of the Michigan-Huron basin in the period 1880–1884 averaged 124,300 c. f. s. as compared with 90,600 c. f. s. for the years 1920–1923, a decrease of 33,700 c. f. s., and this accounts for 1.69 feet, or 20.3 inches. Reduced water production of the upper lakes is therefore adequate to account for a total lowering of the levels of Michigan-Huron since 1885 of roundly 36 inches. The present depression of over 4 feet in the levels of these lakes is made up as shown in the table next following.

Sources of present depression of Lakes Michigan-Huron

Diversion	6 to 8 inches.
Channel improvement	8 to 10 inches.
Deficient water production:	
Lake Superior basin	13.5 inches.
Michigan-Huron basin	20.0 inches.
Total	49.5 to 53.5 inches.

Several years must elapse before deficiency in supply exercises its full effect on lake levels. The depression due to low rainfall in very recent years has not yet been fully realized, and if present low rainfall continues some further drop in levels will occur. The figures given represent the total drop to be expected from past rainfall deficiency. The total indicated depression is, therefore, somewhat greater than the actual depression of lake levels thus far experienced.

The question naturally arises, Will the rainfall on the Great Lakes drainage basin remain permanently reduced or will it return to a higher level? The longest existing rainfall records show two facts:

(1) Long and apparently irregular, aperiodic, secular variations in rainfall are characteristic of such records.

(2) There is little evidence of a real permanent change of rainfall of an appreciable amount.

In conclusion the authors say:

> These facts are illustrated by the rainfall record of Padua, Italy, and New Bedford, Mass., the latter being one of the longest American records. These both show long irregular cycles of high and low rainfall, respectively. Similar conditions must be expected for the Great Lakes region. The present cycle of low rainfall will sooner or later come to an end, but long cycles of low-rainfall years must occur in the future as they have in the past. When a cycle of higher rainfall years occurs, lake levels will rise, but even if all diversions were stopped and adequate compensation were made for channel improvements a long period of time must elapse before Lakes Michigan-Huron would be restored to their normal levels. The restoration would not be permanent, but cycles of depression would be repeated from time to time, corresponding to cycles of low rainfall. The only complete and adequate remedy is regulation. This is the only means that will provide definite, stable lake levels for all future time.

TORNADO AT CINCINNATI OHIO, JANUARY 19, 1928

By W. B. SCHLOMER

A tornado of very limited extent, and the second authentic storm of such character to visit Cincinnati since official records began, caused considerable damage over a small area in the Mill Creek Valley section of Cumminsville, in the northwestern portion of Cincinnati. It is probably the first time that a storm of this type occurred in this latitude of the Ohio Valley near midwinter.

Meteorological conditions at 8 a. m. January 19, 1928, showed a deep storm central over Lake Michigan with a troughlike extension southward over the lower Ohio Valley. Thunderstorms had occurred during the preceding 12 hours over the region from the lower Ohio Valley westward to Missouri. The pressure had been falling steadily during the last 24 hours, with a rather rapid fall between about 2 a. m. and 8:50 a. m. The weather had been quite dark during the morning, artificial light being necessary in offices, stores, etc. At 9. a. m. the darkness became more pronounced, causing comment and inquiry. At 9:07 a. m. there was a sudden and decided diminution in the brilliancy of the electric lights in the office and elsewhere in the city. It is believed that this fixes the time of the tornado and also corresponds with the Union Gas & Electric Co.'s record of trouble on their power lines. It was also at this time that Mr. J. T. Gray, on duty at the Abbe Meteorological Observatory, reports having heard an unusual roar in the west and the sky black and threatening. The path of the tornado was about 1 mile west of the Abbe Observatory.

First evidences of the tornado appear over the region immediately west of Spring Grove Avenue, between Ralston Street and Mill Creek Bridge. The tornado moved in a northeasterly direction. Along Spring Grove Avenue its track was apparently about 500 feet wide. Except for overturned chimneys, all evidence of destruction disappears about 200 feet east of Colerain Avenue, and it is estimated that the path of the tornado was about 1,000 feet long and varied in width from about 500 feet to 200 feet. A number of eyewitnesses claim to have observed the funnel-shaped cloud accompanied by balls of fire. It is believed that this latter was due to short-circuited fallen electric wires. Aside from these eyewitnesses the débris in several places bears evidence of tornadic action, and some buildings show the explosive force of the air as the vortex passed. Fortunately no lives were lost. About 18 people suffered injuries, none serious, and the total property damage is estimated at about $100,000.

Records made at both the Abbe Meteorological Observatory and the Government Building, 1 and 4 miles, respectively, from the scene of the tornado do not show any close connection with the storm. At the Government Building there was a sudden backing of the wind from east to west at 8:50 a. m. and a simultaneous rise of 0.09 in inch pressure followed by a rather sharp drop of 0.10 inch. At the Abbe Meteorological Observatory brisk southerly winds shifted to southwest at 9 a. m., and at about 9:09 a. m. a moderately heavy rain was coincident with a sudden pressure rise of 0.04 inch.

TORNADOES AT LOUISVILLE, KY., JANUARY 19, 1928

By J. L. KENDALL

Two small tornadoes descended upon the outskirts of Louisville on the date above mentioned and under atmospheric conditions as described in the above article. The storm was associated with a thunderstorm and the wind-shift line of the cyclone.

The first and most intense of the two had its origin about 1 mile southwest of Shively, Jefferson County, Ky., and moved east-northeast to a point near Anchorage, Ky., a distance of about 18 miles.

The second tornado originated about 12 miles almost due east of the origin of the first and moved in a path parallel thereto for a distance of but 4 miles, beginning near Fern Creek and ending near Jeffersonton. The damage wrought by these storms is given on page 25.

As in the case of the tornado of March 18, 1925, which traversed a district but a few miles south of this one, the tendency of the tornadic winds was to rise as distance to the east was gained. After passing through the southern part of the city they touched the earth only occasionally.

A MIDWINTER SHOWER IN NORTH DAKOTA

By WILLIAM J. BERRY

A light shower of rain accompanied by high temperature for the season occurred at Grand Forks, N. Dak., during the night of December 4–5, 1927. The rain began about 11 p. m. It did not freeze on trees and telephone wires but the ground surface soon became glazed over. The temperature, which for several days had been around and below zero, Fahrenheit, stood at 9 below zero at 9 a. m. on the 4th; it rose rapidly thereafter reaching 36° above by the following midnight, a rise at the rate of 3° per hour for a 15-hour period. The wind, which was fairly strong from the south-southeast on the 4th, decreased to a speed of barely 4 miles per hour at midnight of the 5th, shifting to northwest at that hour and increasing to 30 miles per hour at 7:45 a. m. on the 5th.

DISCUSSION

The conditions above described were due to the rather rapid eastward movement of a well-defined cyclonic system which crossed the meridian of Grand Forks about the time of highest temperature. The center of the system was to the northward of Grand Forks and the barometric gradient was for southerly winds.

Kite observations made at Ellendale, N. Dak., on the dates in question show the following:[1]

"An unusually large rise in the surface temperature accompanying a northwesterly wind at Ellendale on December 4–5 makes the upper air records for those dates

[1] Reported on by L. T. Samuels, of the Aerological Division.

of special interest. On the morning of the 4th this station was between a low pressure area to the north and a high to the southward. The surface temperature (−28° C.) began rising about 9 a. m. of the 4th and continued steadily until 4 a. m. of the 5th when it had reached 3° C., an increase of 31° C. in 19 hours. During this period the surface wind changed from southwest to south, again to southwest, then to west and finally northwest. It is noticed that a considerable portion of the rise in temperature occurred after the south component had disappeared, the wind having become westerly and northwesterly some 6 hours before the temperature rise ceased.

A kite flight made at noon of the 4th revealed a moderate southerly surface wind veering with increase in altitude to strong northwesterly at and above 2,000 meters. A pronounced inversion prevailed just above the surface, the temperature increasing from −20.6° C. to −5.9° C. at 370 meters, or −3.98° C. per 100 meters. From the latter altitude to the maximum (2,386 meters above surface) the average lapse rate was only 0.19° C. per 100 meters. The record of the morning of the 5th showed a northwesterly surface wind backing with altitude to westerly at 2,000 meters and above. By this time the surface temperature had risen considerably as previously mentioned but, above what on the day before was the upper limit of the surface inversion (370 meters), the temperatures remained practically the same.

Relatively warm west and northwesterly air currents such as occurred on this occasion are characteristic of this region and are associated with low-pressure areas. The trajectory of this air, instead of being from the cold Arctic regions is evidently from the warm Japanese current of the Pacific."

METEOROLOGICAL SUMMARY FOR SOUTHERN SOUTH AMERICA, DECEMBER, 1927

By J. Bustos Navarrete

[Observatorio del Salto, Santiago, Chile]

In December, 1927, there was very little activity in the atmospheric circulation. Frequent depressions of stationary character situated off the coast of central Chile brought much cloudiness and morning fog.

Only one depression of true cyclonic type was observed; this storm, which crossed the region of Magallanes on the 1st, caused strong winds, rain and foul weather generally over a large part of the southern area.

The anticyclones which formed over the islands of Juan Fernandez and Chiloe were, however, more numerous; the most important of these appeared on the charts for the following periods: 6th–7th, 8th–9th, 14th–15th, 20th–21st, 25th, and 28th–31st.

Precipitation was relative light in southern Chile and was generally limited to the region between Arauco and Magallanes. At Valdivia the total fall for the month was only 1.81 inches (normal, 4.41 inches).

While along the central coast there was much cloudiness, frequent morning fog and rain, in the interior the weather was uniformly fine. Throughout the first two weeks temperatures were moderate, and a definite change to warmer, with maxima 86° to 90° F., did not come until after the 25th.—*Transl. by W. W. R.*

METEOROLOGICAL SUMMARY FOR BRAZIL, DECEMBER 1927

By Francisco de Souza, Acting Director

[Directoria de Meteorologia, Rio de Janeiro]

The circulation in the lower strata of the atmosphere was abnormally intense; seven anticyclones swept over the Brazilian territory and in addition the depressions over the continent and high latitudes showed the usual activity. The active secondary circulation caused moderate storms on the southern coast.

In all of Brazil rainfall was generally light, especially in the higher latitudes, where the monthly total averaged 2.25 inches below normal.

Over the greater part of central and southern Brazil coffee, cotton, sugar cane, cereals, and vegetables suffered from lack of sufficient rain.

Fine weather prevailed in Rio de Janeiro; the duration of sunshine was 66.5 hours in excess of the normal for the month and the total precipitation showed a deficiency of 3 inches. The maximum temperature was 96° F. There were two storms; during the heavier one on the 15th the wind reached a velocity of 42 miles per hour from the south-southwest.—*Transl. by W. W. R.*

NOTES AND ABSTRACTS

A PROTOTYPE OF THE PUBLICATION "WORLD WEATHER RECORDS" [1]

The editor, in common with many others, welcomed the appearance of the volume here considered, but the welcome was somewhat dimmed by the discovery that the record for practically all of the meteorological stations comprising the great network maintained by Russia during the period antedating the World War began with the year 1881, whereas the observations began 10 to 12 years earlier. The omission of the early records seems not to have been due to the committee that collected the original data.

While in the Weather Bureau library a short time since, the attention of the editor was called to the second volume of the 1878 Yearbook of the Royal Meteorological Institute of The Netherlands, published in 1886 and prepared by a no less competent person than the late H. Wild, who for many years was director of the Central Physical Observatory at St. Petersburg (now Leningrad). This publication contains the monthly mean pressures and temperatures for practically all stations on the globe, wherever situated, that were in operation in the late seventies. The record begins with January, 1871, and concludes with December, 1882, thus bridging the gap that exists in the publication, "World Weather Records," above mentioned. The monthly means of pressure, however, do not form a homogeneous series with those given in the last named publication.—*A. J. H.*

[1] Smithsonian Misc. Coll., vol. 79, World Weather Records, collected by a committee, assembled and published by H. Helm Clayton, 1927.

RADIO BROADCASTS OF TWICE-DAILY WEATHER REPORTS

For several months past the U. S. Weather Bureau, with the cooperation of the Navy Department, has broadcast the morning weather reports from more than 200 station in the United States and Canada. Beginning on February 1, 1928, the complete reports both morning and evening will be broadcast at 8:15 a. m. and 8:15 p. m. eastern standard time in cooperation with the

Office of Communications of the Navy Department by distant control connection with the naval radio station (NAA) at Arlington, Va.

The reports are expressed in the regular Weather Bureau Code, which may be translated at sight after a very short study of the key to the system. These broadcasts afford the means of the widest possible distribution of the twice-daily weather reports from all parts of the country for the use of both the Army and the Navy, commercial and Government aviation fields, business organizations and individuals who may have need of the information at an earlier hour than has been possible to release it.

Two other broadcasts are made at 11 a. m. and 11 p. m. for the benefit of European weather services. The weather reports in these broadcasts are expressed in the International Numeral Code. Information relative to that code may be obtained on application to the Weather Bureau at Washington, D. C.

FREE-AIR CONDITIONS IN NORTHEAST OKLAHOMA FAVORABLE TO LOCAL PRECIPITATION

J. A. RILEY

The official in charge of the Weather Bureau kite station at Broken Arrow, Okla., writes as follows regarding the free-air conditions favorable to the occurrence of precipitation at his station:

I visualize the conditions under which precipitation occurs in this region under pressure distributions of this kind as a ridge of air which takes the place of a mountain range over which the winds are blowing, with precipitation on the windward side. A number of times when such a condition occurred we could not get a kite up or it was unsafe. We felt sure that a south wind was blowing at some distance aloft, and we arrived at this conclusion by the sound of some machinery which runs night and day south and southeast of the station. This can hardly be heard when north winds prevail at all altitudes. But if there is a south wind anywhere within the first kilometer, the sound is plainly audible. On November 9, 1927, we made a flight in such a condition. Shortly after the head kite was launched in a northeast wind the surface wind practically died out, and the light fog became denser throughout the flight and was dense at the end. The kites veered through east and south into a southwest wind at the highest point reached. It had been raining for some time before the flight with a moderate shower from 7:08 a. m. to 7:18 a. m. The weather map shows a slight bulge of the HIGH just north of us on that morning, and rain all over the southern side of the HIGH in the Eastern States. We have no upper air data here except our own but I am of the opinion that these rains were caused by southerly winds rising and flowing across the HIGH.—*J. A. Riley.*

While it was impossible to obtain pilot-balloon observations over the region near to Oklahoma because of rain and low clouds, the kite flight at Due West, S. C., revealed a somewhat similar structure in the free air above that place from which it may be inferred that there was a very sharp shift in the wind aloft on the boundary between relatively cold lower airlayers and a southerly current above.—*Welby R. Stevens.*

THE WIDESPREAD MENACE OF HAIL [1]

By S. D. FLORA

The year 1927 was characterized by six days, each having very severe hailstorms in Oklahoma, Kansas, eastern Colorado, and Texas. The total crop loss from these storms aggregated from five to seven millions. The exact total due to hail alone can not be determined since it is impossible to segregate losses due to hail and high winds combined. The days with severe hailstorms were May 4–5 and June 1–4, 1927.

The total estimated loss in 1927 from 298 storms was in excess of $15,000,000. In 1926 there were 295 storms and a total loss of $12,000,000. In 1925 the number of storms was only 225.

In the States of Oklahoma, Kansas, Colorado, Texas, Iowa, Illinois, and Nebraska single storms wrought a damage in excess of a million dollars and an outstanding storm in Kansas on June 2 caused estimated loss of two millions because of the destruction of 30 square miles of promising wheat about ready for the harvest.

Reference is made to notable storms throughout the United States in recent years.

CHINOOK EFFECTS IN ALBERTA, JANUARY 4, 1928

Mr. A. Griffin, of Brooks, Alberta, submits the following:

Jan. 4, 1928, 3 p. m. It may be worth reporting that it rained 0.03 inch this morning between 9:30 and 11 a. m. The raindrops were small but did not freeze until they reached the ground. Temperatures recorded to-day are as follows:

	°F.		°F.
9:00 a. m.	11	1:30 p. m.	24
11:30 a. m.	17	3:00 p. m.	32
12:30 p. m.	24	3:30 p. m.	36

Light chinook blowing by 3 p. m., eaves dripping and snow softening perceptibly. The temperatures for preceding days are as follows:

	°F.		°F.
Jan. 1, 1928, max.	−24,	min.	−38.
Jan. 2, 1928, max.	−11,	min.	−33.
Jan. 3, 1928, max.	14,	min.	−26.
Jan. 4, 1928, max.	32,	min.	−10.

At 3 p. m. barometer falling slightly from 26.63 inches at 9 a. m. Cloudy up to about noon, low clouds. Cleared up shortly after noon.

Mean of maximum and minimum temperatures for December, 1927, was −2.7° F. and average for the 12 preceding Decembers is 17.9° F.

The weather chart for January 4, 8 a. m., seventy-fifth meridian time, shows a rather large area of higher temperatures in the last 24 hours stretching from Alberta south to Helena, Mont., the eastern edge of which had not yet reached Brooks Station.—*A. J. H.*

[1] Abstract.

JANUARY WEATHER IN THE UNITED STATES 50 YEARS AGO

January, 1878, was characterized by high temperatures in the northern half of the country, especially in the upper Mississippi and Missouri Valleys, including Minnesota. Rainfall was greater than normal in both Atlantic and Pacific Coast States. The coastal waters of the Atlantic were visited by two severe storms in one of which the S. S. *Metropolis* foundered off the North Carolina coast, with a loss of 100 lives. Very high winds were recorded—120 miles per hour at Cape Lookout, N. C., and the unprecedented velocity of 186 miles per hour (uncorrected), at Mount Washington, N. H.—*A. J. H.*

NOTES

M. Koenig in Miscellaneous publications of the Royal Alfred Observatory, Port Louis, Mauritius, No. 6, gives an account of a cyclone which passed from northeast to southwest north of Mauritius on February 27, 1927. After passing that island the cyclone changed its direction of movement to west-northwest and struck the coast of Madagascar at or close to Tamatave on March 3, 1927, with a very considerable increase in intensity. This cyclone is the first case of record in that part of the Indian Ocean, of a cyclone actually moving toward the Equator.—*A. J. H.*

We reprint from Science Abstracts, volume 30, page 853, a discussion by G. Abetti (Accad. Lincei, Atti, 5, pp. 721–726, May 15, 1927). This discussion consists almost entirely of a review of the work of previous investigators, the object of the paper is to draw attention to a few of the most noteworthy cases in which spectroheliographic observations have with some probability established a correspondence between a given solar eruption and a terrestrial magnetic storm, and, confirming the hypothesis of Tacchini and Hale, have assigned a value to the velocity of transmission of the perturbations from the sun to the earth. It appears from these observations that a mean period of 25.6 hours intervenes between the solar eruption and the commencement of the magnetic storm, and that a velocity of transmission of about 1,600 km./sec. may therefore be considered as fairly well established.—*E. F.*

Wireless telegraphy.—The influence of surfaces of atmospheric discontinuity, polar fronts, on the propagation of short waves.

On a cruise off Norway and Iceland during April and May, 1927, the dispatch boat *Ville-d'Ys* maintained a regular service of sending meteorological reports by wireless six times each day. The messages were sent simultaneously on lengths of 65 and 24 meters, respectively, and were received in the vicinity of Paris and also in the interior and on the coasts of France.

M. Georges-Henri Huber has investigated this service with reference to the influence of atmospheric discontinuity, polar front, on the propagation of short waves. In *Comptes Rendus de l'Academie des Siences*, 185, 1927, page 935, he presents the following conclusions:

(1) The surfaces of discontinuity in the atmosphere present an obstacle to the propagation of short waves. This is especially clear for the polar front, properly named, which often presents very sharply defined discontinuities. The obstacle is, furthermore, all the more serious when the part of the front situated between the two stations exchanging messages is well marked.

(2) With a surface of discontinuity forming two angles with the ground, one acute and the other obtuse, the station situated within the acute angle finds broadcasting subject to much less interference than that affecting reception. It has been seen that such a station could very well be unable to hear its correspondents on the other side of the front and yet be heard by them. It appears, in addition, that the nearer the front the correspondents are situated, the more considerable does the obstacle become.—*W. W. R.*

An article from the Times correspondent at Delhi, in the issue of January 12, conveys the welcome news that a great new meteorological observatory at Poona is to be brought into use this summer, thus carrying into effect a scheme proposed in 1924 for transferring the headquarters of the Indian weather department thither from Simla. The difficulties that have led to the transfer are not limited to the tropics. On one hand, it is vital that the routine work of daily forecasting and of administration shall be well carried on, for it is on performance of these tasks that revenue depends, and with that the chance of scientific progress. Further, there is a material gain of efficiency if the staff can be collected into the same station, facilitating cooperation as well as access to laboratories and libraries. There is, therefore, a tendency for the ablest men to gravitate to headquarters. But Simla can not employ kites because winds are too light, or instrument-carrying balloons because of the wild mountain regions in which they would be lost; so experimental examination of the physical processes of weather can scarcely be effected there, and bringing up an officer from a provincial observatory very seriously reduces his chance of advancing knowledge and of keeping in living contact with science. The remedy adopted by the department in India has been to give up the advantage of being at the seat of government and to transfer its headquarters to Poona, where upper air work is possible and monsoon conditions, unlike those of the western Himalayas, are representative of India. Poona has the further advantages of a good climate and of proximity to Bombay, so that closer relationships can be maintained with shipping and commercial interests.

The Times correspondent says, however, that the object of the new observatory is "special research work with a view to elaborate and accurate forecasting of the southwest monsoon." Also "The Meteorological Department * * * is now able regularly to forecast in mid-October the quantity of rainfall in northern India in the next five months. The indications are given to within a fraction of an inch, and during twelve years wherever the system has been followed it has never proved fallacious." *On reading this surprising account, it is natural to inquire into the recent success of the method and we find Mr. Field in his forecast of January 6 last, after rightly deprecating undue confidence, saying that the high-level winds were "about normal in character." The total actual precipitation, as described on June 27, was, however, not normal but "in moderate defect." Again in the previous year the high-level winds were "stronger than usual"; and the total actual precipitation was not in excess as it should have been, but "in slight defect." In spite of this lack of perfection, we are convinced that upper-air data promise to be of great value for seasonal forecasting after twenty or thirty years of data have been accumulated; but friends of the department should lay stress on the value of the upper-air work done ot Poona for aerial navigation and daily forecasting, rather than arouse expectations of an early revolution in methods of seasonal prediction. Confidence in long-range forecasts can only be built up slowly, and is more easily lost than won.—Reprinted from Nature, London, January 21, 1928.*

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING JANUARY, 1928

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, **52:** 42, January, 1925, **53:** 29, and July, 1925, **53:** 318.

Table 1 shows that solar radiation intensities were above the normal values for January at all three stations. At Lincoln, Nebr., an intensity of 1.53 gram-calories per minute per square centimeter measured at noon of the 20th slightly exceeds the maximum January intensity previously measured at that station.

Table 2 shows a slight excess in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky at Washington and Lincoln, and a slight deficiency at Madison, as compared with the January normals for these stations.

Skylight polarization at Washington made on four days give a mean of 57 per cent, with a maximum of 62 per cent on the 10th. These are slightly lower than the corresponding normal values for Washington for January.

At Madison no polarization measurements were made during the month on account of the presence of ice and snow.

TABLE 1.—*Solar radiation intensities during January, 1928*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass, A. M.: 5.0	4.0	3.0	2.0	[1] 1.0	P. M.: 2.0	3.0	4.0	5.0	Local mean solar time
	e.										e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Jan. 4	1.52	0.75	0.86	1.05	1.29	1.58		1.15	1.01	0.92	0.96
Jan. 10	3.63	0.94	0.98	1.08	1.27	1.52		1.13	1.02	0.80	3.81
Jan. 11	3.99				1.29			1.05			6.27
Jan. 12	3.81	0.70	0.84	1.00	1.20	1.43					4.17
Jan. 20	2.49				1.30			1.15			2.26
Jan. 21	0.91						1.30				0.86
Jan. 23	1.88	0.87	0.98	1.12	1.32	1.54	1.35	1.09	0.93	0.87	2.16
Jan. 25	2.49			1.09	1.33						2.36
Jan. 26	2.06						1.37	1.14	0.96		3.99
Jan. 27	1.68				0.92		1.14	0.87	0.67		1.88
Jan. 30	1.10		0.65	0.86							1.37
Means		0.82	0.86	1.03	1.24	1.52	1.29	1.08	0.92	0.89	
Departures		+0.09	+0.01	+0.03	+0.01		+0.06	+0.05	+0.05	+0.10	

MADISON, WIS.

Date	8 a.m.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon
Jan. 3	0.79			1.21				1.26			1.07
Jan. 4	1.22							1.06			1.88
Jan. 21	0.91		1.10	1.23	1.39			1.24			1.12
Jan. 23	1.96	0.98	1.07								3.99
Jan. 25	1.24	0.93	1.16	1.27							1.52
Jan. 28	0.48		1.17	1.30							0.71
Jan. 30	1.37							1.05			1.52
Means		(0.96)	1.12	1.25	(1.39)			1.15			
Departures		+0.00	+0.04	+0.02	+0.03			−0.06			

LINCOLN, NEBR.

Date	8 a.m.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon
Jan. 3	0.58	0.97	1.10	1.24	1.41						1.24
Jan. 5	1.45								0.93	0.78	4.75
Jan. 8	3.00							1.29	1.17	0.90	3.63
Jan. 14	3.99	0.89	0.92	1.23							4.75
Jan. 19	3.15	0.94	1.18	1.24				1.03	0.88	0.72	2.06
Jan. 20	0.71	1.12	1.24	1.40	1.54	1.70		1.38	1.24	1.11	0.51
Jan. 21	0.96	0.79	1.02	1.18	1.43	1.71	1.43				1.60
Jan. 22	1.96						1.43				2.26
Jan. 23	2.62		0.92								3.99
Jan. 24	1.32			1.29	1.44			1.23	1.08	0.99	1.52
Jan. 25	1.19			1.12	1.45		1.46	1.27	1.16	1.05	1.19
Jan. 26	0.71		1.08	1.20							0.66
Jan. 27	1.37	1.10	1.22	1.32							1.19
Means		0.97	1.08	1.25	1.45	(1.70)	1.44	1.24	1.08	0.94	
Departures		+0.04	+0.03	+0.07	+0.07		+0.02	+0.07	+0.03	+0.01	

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation: Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Average daily departure from normal: Washington	Madison	Lincoln
1928									
Jan. 1	179	136	211	113	130	117	−27	−1	+25
Jan. 8	164	128	192	83	77	151	−9	−21	−4
Jan. 15	146	127	167	73	127	199	+14	−35	−34
Jan. 22	221	211	241	118	150	192	+38	+23	+19
Excess or deficiency since first of year on Jan. 28							+112	−238	+42

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory]

[Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories]

(The differences of longitude measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column)

Date	Eastern standard civil time	Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1928	h. m.	°	°	°			
Jan. 1 (Naval Observatory)	11 39	−66.0	354.7	−9.0	77		
		−32.0	28.7	−9.5	31		
		−29.5	31.2	+6.5	25		
		−28.0	32.7	−8.5	278		
		−22.0	38.7	−7.0		31	
		−7.0	53.7	−14.5		93	
		−6.5	54.2	−18.0		62	
		−2.0	58.7	−15.0		62	
		+36.5	97.2	+8.5		62	
		+68.0	128.7	+13.0		93	
		+75.0	135.7	+12.5	185		999
Jan. 2 (Naval Observatory)	11 54	−59.0	348.4	+11.0	31		
		−53.5	353.9	−9.0	62		
		−24.0	23.4	−12.0		62	
		−19.0	28.4	−8.5		15	
		−15.5	31.9	−8.5	278		
		−8.0	39.4	−7.5		15	
		+1.5	48.9	−14.5	15		
		+4.0	51.4	+11.5		31	
		+8.5	55.9	−18.5		108	
		+9.0	56.4	−15.0		62	
		+13.0	60.4	−17.0		46	
		+32.0	79.4	−34.0	12		
		+49.0	96.4	+10.5		46	783
Jan. 3 (Naval Observatory)	11 51	−71.0	323.2	−17.5		62	
		−45.5	348.7	+10.5		31	
		−39.5	354.7	−9.5	46		
		−11.5	22.7	−11.0		62	
		−5.5	28.7	−8.5	9		
		−2.0	32.2	−8.5	300		
		+22.0	56.2	−17.0		340	
		+28.0	62.2	−15.5		46	905
Jan. 4 (Naval Observatory)	11 59	−58.5	322.5	−18.0		154	
		−32.0	349.0	+10.5	31		
		−26.5	354.5	−9.5	46		
		−6.0	15.0	+12.0	9		
		+2.0	23.0	−11.0		46	
		+8.5	29.5	−8.0	12		
		+12.5	33.5	−8.5	293		
		+20.0	41.0	−7.5		15	
		+36.5	57.5	−17.0		202	
		+41.0	62.0	−15.5		15	883
Jan. 5 (Naval Observatory)	11 47	−74.0	293.9	+14.0		77	
		−45.5	322.4	−18.5		185	
		−18.0	349.9	+10.0	31		
		−12.0	355.9	−9.5	46		
		+7.5	15.4	+11.0		77	
		+15.5	23.4	−12.5		46	
		+21.5	29.4	−8.5		15	
		+26.5	34.4	−8.5	203		
		+49.0	56.9	−17.5		216	986
Jan. 6 (Naval Observatory)	11 45	−60.0	294.8	+14.0		77	
		−55.0	299.8	+12.5	46		
		−31.5	323.3	−18.5		185	
		−4.5	350.3	+10.0	31		
		+1.5	356.3	−9.5	46		
		+21.0	15.8	+10.5		108	
		+39.5	34.3	−8.5	293		
		+63.0	57.8	−17.5		185	971
Jan. 7 (Naval Observatory)	11 48	−50.0	291.6	+11.0		77	
		−46.0	295.6	+14.0	31		
		−40.5	301.1	+12.0	22		
		−17.0	324.6	−18.5		185	
		+9.5	351.1	+10.0	15		
		+15.0	356.6	−9.5	31		
		+31.5	13.1	+10.5		62	
		+37.5	19.1	+10.0		77	
		+52.5	34.1	−8.5	340		840
Jan. 8 (Naval Observatory)	11 42	−73.0	255.4	−9.0	31		
		−36.5	291.9	+10.0		46	
		−27.0	301.4	+12.5	6		
		−8.0	320.4	−19.5		25	
		−1.0	327.4	−18.0		123	
		+2.0	331.4	−6.5		46	
		+16.5	344.9	+12.0		18	
		+22.5	350.9	+11.0		15	
		+28.0	356.4	−9.5	15		
		+46.0	14.4	+10.5		77	
		+49.0	17.4	−15.0	9		
		+51.0	19.4	+10.0		93	
		+67.0	35.4	−8.0	278		782

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic: Diff. long.	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day
1928	h. m.	°	°	°			
Jan. 9 (Yerkes)	13 40	−23.0	291.0	+9.0	100		
		+13.0	327.0	−16.0	100		
		+56.0	10.0	+13.0	145		
		+65.0	19.0	+12.0	145		
		+78.0	32.0	−5.0	575		1,065
Jan. 10 (Naval Observatory)	12 35	−72.5	229.1	+18.0		62	
		−47.0	254.6	−9.5	15		
		−27.5	274.1	−10.0		108	
		−10.5	291.1	+10.0		77	
		−6.0	295.6	+9.0		77	
		+17.0	318.6	−18.0	108		
		+22.5	324.1	−7.5		31	
		+71.0	12.6	+10.5		77	
		+79.0	20.6	+10.0		77	632
Jan. 11 (Naval Observatory)	11 50	−63.0	225.9	+17.0	15		
		−58.0	230.9	+17.5	40		
		−33.5	255.4	−9.5	6		
		−17.5	271.4	−15.0		31	
		−17.0	271.9	−12.0		77	
		−13.5	275.4	−10.0		247	
		+2.0	290.9	+9.5		123	
		+7.5	296.4	+9.0		62	
		+39.5	328.4	−18.5	123		
		+47.5	336.4	−7.5		15	739
Jan. 12 (Naval Observatory)	11 52	−50.0	225.7	+17.0		31	
		−44.0	231.7	+17.5	37		
		−20.0	255.7	−9.5	31		
		−4.0	271.7	−12.5		216	
		+1.5	277.2	−10.0	154		
		+15.5	291.2	+9.5		93	
		+21.5	297.2	+8.0		62	
		+52.5	328.2	−19.0	123		747
Jan. 13 (Naval Observatory)	13 53	−35.0	226.4	+18.0		31	
		−29.0	232.4	+18.0	31		
		+10.0	271.4	−12.5		216	
		+17.0	278.4	−9.5	154		
		+29.0	290.4	+10.0		77	
		+34.0	295.4	+8.0		62	
		+67.5	328.9	−19.0	123		694
Jan. 14 (Naval Observatory)	13 35	−55.5	192.9	+16.0		31	
		−23.0	225.4	+16.0	3		
		+20.5	268.9	−10.5	22		
		+21.0	269.4	−17.0		93	
		+25.0	273.4	−11.5		15	
		+27.0	275.4	−14.5		93	
		+29.5	277.9	−10.5	123		
		+42.0	290.4	+7.5		77	
		+49.0	297.4	+7.5		77	
		+79.0	327.4	−19.0	123		657
Jan. 15 (Naval Observatory)	13 31	−85.0	150.3	+13.5		247	
		−44.5	190.8	+15.5		46	
		−40.5	194.8	+17.0		31	
		−32.0	203.3	+15.0		31	
		−25.0	210.3	−17.5		6	
		+37.0	272.3	−15.0		93	
		+39.0	274.3	−10.0		154	
		+55.0	290.3	+8.0		62	
		+62.0	297.3	+8.0		123	793
Jan. 17 (Naval Observatory)	12 19	−72.0	137.6	+17.0	525		
		−61.0	148.6	+16.0		586	
		−54.0	155.6	+15.0	31		
		−18.5	191.1	+15.5		46	
		−10.0	199.6	+18.0		31	
		−7.0	202.6	+15.0	31		
		+59.0	268.6	−17.5		40	
		+66.0	275.6	−10.0	154		
		+67.0	276.6	−12.5	62		1,506
Jan. 18 (Yerkes)	11 45	−56.0	141.0	+15.0	380		
		−44.0	153.0	+12.0	480		860
Jan. 19 (Mount Wilson)	12 30	−72.0	111.2	+5.0		205	
		−39.0	144.2	+15.0		972	
		+20.0	203.2	+15.0		3	
		+87.0	270.2	−11.0	130		1,310
Jan. 20 (Naval Observatory)	11 52	−59.0	111.3	+7.0		185	
		−30.5	139.8	+17.0		494	
		−19.0	151.3	+15.5		463	1,142
Jan. 21 (Naval Observatory)	11 47	−46.0	111.2	+7.0		185	
		−17.0	140.2	+17.0		401	
		−5.5	151.7	+16.0		370	956
Jan. 22 (Naval Observatory)	11 35	−47.5	96.7	+9.0		31	
		−32.5	111.7	+7.0		216	
		−4.5	139.7	+17.0		278	
		+6.0	150.2	+16.0		309	834
Jan. 23 (Naval Observatory)	11 45	−83.0	47.9	−20.0	300		
		−32.5	98.4	+8.5		93	
		−19.5	111.4	+7.0		309	
		+7.0	137.9	+17.5		170	
		+19.0	149.9	+16.5		309	
		+21.0	151.9	−8.0		15	1,205
Jan. 24 (Mount Wilson)	14 30	−85.0	31.2	−6.0	402		
		−74.0	42.2	−13.0		133	
		−70.0	46.2	−20.0		705	
		−70.0	46.2	−27.0		20	
		−18.0	98.2	+9.0		142	
		−5.5	110.7	+6.0		401	
		+33.0	149.2	+15.0		638	
		+40.0	156.2	−10.5		104	2,545
Jan. 25 (Naval Observatory)	11 50	−70.0	34.5	−8.0	278		
		−61.0	43.5	−16.0		154	
		−59.5	45.0	−21.0	463		
		−59.5	45.0	−28.0		31	
		−37.0	67.5	−22.5		15	
		−9.0	95.5	+8.0		46	
		−2.0	102.5	+8.5		93	
		+8.0	112.5	+6.0		185	
		+33.5	138.0	+16.0		154	
		+41.5	146.0	+15.0	77		
		+48.0	152.5	+14.5	278		
		+50.0	154.5	−10.0		93	1,867
Jan. 26 (Naval Observatory)	11 54	−57.0	34.3	−8.0	247		
		−47.5	43.8	−16.0		93	
		−47.0	44.3	−22.0		432	
		−22.0	69.3	−22.0		31	
		+4.0	95.3	+8.5	31		
		+13.5	104.8	+8.5		123	
		+20.5	111.8	+6.0		185	
		+47.5	138.8	+16.5		154	
		+54.0	145.3	+15.5	62		
		+60.0	151.3	+14.5		309	
		+63.0	154.3	−10.0		93	1,760
Jan. 27 (Naval Observatory)	11 50	−43.0	35.2	−8.0	278		
		−34.0	44.2	−16.0		77	
		−33.5	44.7	−22.0		401	
		−8.0	70.2	−21.5		31	
		+20.5	98.7	+8.5		77	
		+28.0	106.2	+8.5		139	
		+34.0	112.2	+5.5		154	
		+59.5	137.7	+17.0		154	
		+66.0	144.2	+15.5	77		
		+73.0	151.2	+15.0		247	1,635
Jan. 28 (Mount Wilson)	14 45	−28.0	35.4	−8.0		359	
		−21.0	42.4	−16.5		45	
		−19.0	44.4	−21.5		999	
		+8.5	71.9	−20.5		25	
		+10.0	73.4	−10.0		69	
		+47.0	110.4	+10.0		502	
		+85.0	148.4	+19.0	40		2,039
Jan. 29 (Naval Observatory)	11 50	−17.0	34.9	−8.0		309	
		−7.5	44.4	−22.0		247	
		+20.5	72.4	−21.0		31	
		+21.0	72.9	−10.5		93	
		+55.0	106.9	+8.0		309	
		+61.0	112.9	+7.0		108	1,097
Jan. 30 (Yerkes)	16 1	−2.0	34.0	−8.0	250		
		+9.0	45.0	−23.0	550		
		+32.0	68.0	−11.0	140		
		+38.0	74.0	−12.0	240		
		+70.0	106.0	+7.0	720		1,900
Jan. 31 (Naval Observatory)	12 8	−69.5	315.9	−16.5	46		
		−44.5	340.9	+14.5		31	
		+8.5	33.9	−11.0		15	
		+11.0	36.4	−8.0	185		
		+20.0	45.4	−22.0		309	
		+45.0	70.4	−10.0		9	
		+49.0	74.4	−20.5		15	
		+50.5	75.9	−11.0	77		
		+83.0	108.4	+8.0		309	996
Mean daily area for January							1,138

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR DECEMBER, 1927

[Data[1] taken from Jour. Terrestrial Mag. and Atmospheric Electricity, September-December, 1927, p. 174]

December	Relative numbers	December	Relative numbers	December	Relative numbers
1		11		21	17
2		12	52(?)	22	
3		13		23	32
4		14		24	59
5		15	19(?)	25	60
6		16		26	31(?)
7		17	16	27	52
8	71	18	10	28	
9		19	8	29	
10		20		30	
				31	

[1] Prof. Wolfer's values.

Number of observations, 12; mean, 35.6.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR JANUARY, 1928

[Data furnished by Prof. A. Wolfer, Zurich, Switzerland]

January	Relative numbers	January	Relative numbers	January	Relative numbers
1	58	11	79	21	70
2		12	78	22	52
3		13	54	23	61
4	80	14	61	24	94
5		15	62	25	116
6		16		26	113
7	83	17	75	27	143
8	93	18	62	28	94
9		19		29	89
10	80	20	55	30	69
				31	

Number of observations, 23; mean, 79.2.

FINAL SMOOTHED VALUES OF THE SUNSPOT RELATIVE NUMBERS FOR 1926[1]

[Figures taken from Astronomische Mitteilungen, Zurich, September, 1927, p. 183]

Month	Number	Month	Number
January	71.8	August	61.6
February	70.0	September	60.8
March	62.5	October	71.5
April	38.5	November	60.5
May	64.3	December	79.4
June	73.5		
July	52.3	Year	63.9

[1] These figures replace the provisional values published in the MONTHLY WEATHER REVIEW, July, 1926 (p. 300), and January, 1927 (p. 30).

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Free-air temperatures were mostly above normal at the aerological stations, with the greatest departures occurring at Ellendale and Washington. (See Table 1.) The departures at both of these stations decreased with altitude, with the exception of the 500-meter and 750-meter levels. The fact that only a single observation at Ellendale reached to 4,000 meters explains the large departures found at and above that level.

Relative humidity departures were nearly all negative, whereas those for vapor pressure were about equally divided in sign.

Free-air resultant-wind directions were close to normal, but the velocities were considerably above normal. (See Table 2.)

Surface and upper-air maximum temperature records were exceeded at several stations on the 14th, when an extensive low-pressure area was centered over the middle of the country. Record temperatures occurred at the surface, 1,250 meters and 1,500 meters above Broken Arrow; at 3,500 meters and 4,000 meters above Due West; at the surface, 250 meters, 500 meters, and 3,500 meters above Groesbeck; at the surface, 1,000 meters, 2,000 meters, and 2,500 meters above Royal Center.

A 54 m. p. s. wind from the northwest was observed at 9,500 meters above Groesbeck on the morning of the 2d. This was well substantiated by a nephoscope observation on cirrus clouds made during the afternoon of that day which indicated a velocity of 55 m. p. s. At this time there was a latitudinal surface temperature gradient of 25° C. between this station and the northern part of the United States. On the 5th when the latitudinal surface temperature gradient over this same region was practically zero the winds over Groesbeck averaged 4 meters per second and did not exceed 10 meters per second to at least 10,000 meters.

Examples of pronounced surface-temperature inversions are shown by the kite records of Due West and Broken Arrow on the 6th and 11th, respectively. At the former station the temperature rose 12.7° C. throughout the first 150 meters, and at Broken Arrow the temperature at 390 meters was 16.4° C., while at the surface it was 5.0° C. Both of these observations were made near the center of an anticyclone where conditions were favorable for intense nocturnal radiation.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during January, 1928*

TEMPERATURE (°C.)

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C. (7 meters)[1]	
	Mean	Departure from 10-year mean	Mean	Departure from 7-year mean	Mean	Departure from 11-year mean	Mean	Departure from 10-year mean	Mean	Departure from 10-year mean	Mean	Departure from 3-year mean
Surface	3.8	+0.3	5.2	−0.6	−8.4	+2.2	9.2	+1.2	−4.5	−0.6	3.3	+3.8
250	3.8	+0.3	5.1	−0.6			9.2	+1.4	−4.7	−0.6	2.5	+3.2
500	3.9	+0.7	5.7	+0.4	−8.0	+2.5	9.1	+1.6	−5.5	−0.5	2.5	+3.5
750	3.3	+0.3	5.5	+0.6	−6.1	+3.5	8.6	+1.2	−5.1	0.0	2.2	+3.6
1,000	3.1	0.0	4.7	+0.4	−5.4	+2.8	7.8	+0.4	−5.0	0.0	1.0	+3.1
1,250	2.9	−0.2	4.1	+0.5	−5.7	+1.7	7.5	+0.4	−5.3	−0.2	−0.1	+2.6
1,500	2.5	−0.3	3.2	+0.4	−6.3	+1.2	6.4	−0.1	−6.2	−0.7	−1.2	+2.1
2,000	0.9	−0.5	1.3	+0.4	−8.5	+0.6	4.2	−0.6	−7.4	−0.8	−3.6	+1.2
2,500	−1.1	−0.2	−1.1	0.0	−10.7	+0.6	2.4	−0.3	−8.9	−0.4	−5.9	+0.8
3,000	−3.7	−0.3	−2.8	+0.5	−13.2	+0.7	−0.1	−0.5	−11.3	−0.5	−9.4	−0.6
3,500	−6.5	−0.5	−4.6	+0.9	−16.2	+0.5	−2.7	−0.3	−13.7	−0.4	−11.8	−0.6
4,000	−9.1	−0.3	−5.0	+2.5	−17.3	+2.0	−4.7	−0.4	−16.1	−1.3		
4,500			−7.4	+3.6	−18.7	+3.3	−6.8	−1.1	−19.0	−1.6		

RELATIVE HUMIDITY (%)

Altitude (meters) m. s. l.	Broken Arrow Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure	Washington Mean	Departure
Surface	61	−9	66	−1	74	−7	70	−7	79	0	59	−8
250	61	−9	65	−1			67	−8	79	0	58	−6
500	54	−10	59	−2	71	−8	61	−10	76	+1	55	−5
750	52	−8	56	−2	60	−12	56	−11	68	−2	53	−5
1,000	50	−5	53	−3	56	−9	52	−10	60	−5	53	−5
1,250	48	−3	51	−3	55	−5	47	−10	56	−4	54	−4
1,500	45	−2	50	−2	52	−6	46	−7	55	−2	56	−1
2,000	41	−1	50	+2	50	−7	43	−5	47	−5	58	+2
2,500	40	−1	52	+8	48	−9	39	−6	47	−5	58	+4
3,000	35	−6	43	+3	47	−10	37	−5	40	−13	57	+2
3,500	38	−4	37	0	53	−2	33	−7	34	−21	42	+2
4,000	30	−13	34	−5	47	−6	27	−11	31	−23		
4,500			32	−6	47	−9	26	−11	30	−22		

VAPOR PRESSURE (Mb)

Altitude (meters) m. s. l.	Broken Arrow Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure	Washington Mean	Departure
Surface	5.26	−0.53	6.69	−0.05	2.86	+0.37	9.17	+0.32	4.16	+0.24	5.15	+0.83
250	5.23	−0.52	6.65	−0.01			8.76	+0.26	4.11	+0.27	4.84	+0.70
500	4.75	−0.40	6.43	+0.32	2.79	+0.35	7.80	−0.02	3.83	+0.43	4.64	+0.70
750	4.34	−0.33	6.06	+0.32	2.54	+0.26	6.93	−0.29	3.46	+0.35	4.43	+0.66
1,000	4.05	−0.18	5.49	+0.13	2.37	+0.15	6.02	−0.50	3.02	+0.17	4.12	+0.59
1,250	3.74	−0.07	5.06	+0.17	2.25	+0.10	5.14	−0.69	2.71	+0.12	3.79	+0.50
1,500	3.40	0.00	4.61	+0.27	2.0[illegible]	+0.02	4.55	−0.65	2.37	+0.02	3.63	+0.53
2,000	2.74	−0.02	3.89	+0.39	1.70	−0.04	3.48	−0.65	1.90	−0.03	3.05	+0.42
2,500	2.38	+0.05	3.30	+0.66	1.33	−0.09	2.45	−0.86	1.40	−0.24	2.33	+0.20
3,000	1.85	−0.13	2.46	+0.47	1.02	−0.08	1.67	−0.94	1.01	−0.41	1.72	−0.09
3,500	1.63	−0.08	1.30	−0.13	0.91	+0.11	0.88	−1.18	0.84	−0.40	1.02	−0.09
4,000	1.08	−0.36	0.96	−0.24	0.86	+0.27	0.26	−1.41	0.16	−0.80		
4,500			0.66	−0.35	0.84	+0.25	0.13	−1.30				

[1] Naval Air Station, Anacostia, D. C,

TABLE 2.—*Free-air resultant winds (m. p. s.) during January, 1928*

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)			
	Mean		10-year mean		Mean		7-year mean		Mean		11-year mean		Mean		10-year mean		Mean		10-year mean		Mean		8-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	S. 43 W.	2.0	S. 48 W.	1.2	S. 87 W.	3.7	N. 78 W.	1.5	N. 72 W.	5.0	N. 65 W.	3.1	S. 20 W.	1.5	W.	0.5	S. 67 W.	4.6	S. 54 W.	2.2	N. 71 W.	2.0	N. 42 W.	1.5
250	S. 42 W.	2.3	S. 43 W.	1.3	S. 86 W.	4.1	N. 83 W.	1.7					S. 18 W.	2.5	S. 81 W.	0.7	S. 64 W.	5.2	S. 53 W.	2.6	N. 81 W.	6.1	N. 69 W.	3.7
500	S. 50 W.	4.7	S. 39 W.	2.6	S. 86 W.	6.9	S. 88 W.	3.2	N. 68 W.	6.1	N. 69 W.	3.7	S. 37 W.	3.4	S. 56 W.	1.9	S. 68 W.	9.8	S. 61 W.	5.4	N. 81 W.	8.6	N. 73 W.	6.1
750	S. 61 W.	5.4	S. 45 W.	3.2	S. 86 W.	9.1	S. 85 W.	4.8	N. 57 W.	9.3	N. 65 W.	5.8	S. 43 W.	4.1	S. 57 W.	3.0	S. 80 W.	12.3	S. 70 W.	7.1	N. 79 W.	9.4	N. 72 W.	7.8
1,000	S. 77 W.	6.0	S. 61 W.	3.9	S. 88 W.	10.1	S. 83 W.	6.1	N. 56 W.	10.4	N. 63 W.	7.0	S. 41 W.	4.4	S. 61 W.	3.7	S. 88 W.	12.8	S. 78 W.	8.1	N. 78 W.	10.4	N. 69 W.	8.1
1,250	S. 80 W.	6.3	S. 72 W.	4.4	N. 89 W.	11.8	S. 88 W.	8.3	N. 53 W.	11.1	N. 62 W.	8.0	S. 51 W.	5.2	S. 68 W.	4.8	N. 88 W.	13.5	S. 83 W.	9.1				
1,500	S. 83 W.	7.3	S. 75 W.	5.5	N. 88 W.	13.3	S. 88 W.	10.5	N. 57 W.	12.1	N. 63 W.	8.5	S. 58 W.	7.3	S. 71 W.	6.0	N. 88 W.	14.3	S. 86 W.	10.3	N. 76 W.	12.5	N. 70 W.	10.5
2,000	N. 89 W.	9.7	S. 84 W.	7.6	N. 84 W.	14.1	S. 89. W.	12.8	N. 54 W.	14.4	N. 64 W.	11.1	S. 67 W.	7.6	S. 78 W.	7.2	N. 87 W.	16.7	S. 86 W.	12.1	N. 78 W.	13.8	N. 73 W.	11.8
2,500	N. 72 W.	10.9	W.	9.0	N. 87 W.	14.4	W.	15.1	N. 55 W.	15.8	N. 65 W.	13.1	S. 66 W.	8.0	S. 80 W.	8.5	S. 88 W.	17.8	W.	13.7	N. 76 W.	16.0	N. 80 W.	14.2
3,000	N. 67 W.	10.7	N. 87 W.	10.2	N. 85 W.	15.6	S. 88 W.	16.4	N. 49 W.	17.0	N. 65 W.	14.6	S. 74 W.	8.9	S. 81 W.	9.9	N. 83 W.	17.6	W.	14.2	N. 78 W.	18.5	N. 81 W.	15.4
3,500	N. 66 W.	11.0	N. 84 W.	10.9	N. 84 W.	17.2	S. 86 W.	16.3	N. 48 W.	18.4	N. 66 W.	15.6	S. 82 W.	10.4	S. 83 W.	11.2	N. 72 W.	15.1	S. 85 W.	13.4	N. 71 W.	15.0	N. 78 W.	17.0
4,000	N. 62 W.	9.2	N. 83 W.	10.9	N. 70 W.	14.9	S. 87 W.	15.5	N. 35 W.	18.0	N. 62 W.	16.9	N. 88 W.	10.2	S. 74 W.	12.1	N. 57 W.	13.7	S. 81 W.	15.9	N. 79 W.	17.0	N. 82 W.	18.2
4,500	N. 22 W.	12.0	N. 85 W.	10.6	N. 45 W.	15.0	N. 73 W.	14.6	N. 22 W.	18.0	N. 54 W.	19.0	W.	13.0	S. 74 W.	14.2	N. 69 W.	17.2	S. 88 W.	18.4	N. 76 W.	19.3	N. 77 W.	17.3
5,000					N. 45 W.	13.0	N. 54 W.	16.2									N. 45 W.	23.0	N. 45 W.	23.0	N. 74 W.	19.2	N. 81 W.	19.3

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

The important features of the weather during January, 1928, were the strong cold wave existing during the first few days over the districts from the plateau region eastward, and the widespread deficiency in the amounts of precipitation as compared with the normals for the month over practically all parts of the country.

PRESSURE AND WINDS

As the month opened a strong anticyclone, attended by severe cold, that had entered the northwestern United States near the close of 1927 had advanced into the Great Plains with center of highest pressure, nearly 31 inches, over the Dakotas and eastern Montana. At the same time a cyclone of considerable importance was passing down the St. Lawrence Valley, and conditions favored clear and cold weather over the entire country from the Rocky Mountains eastward.

As the anticyclone moved eastward and southward during the following day or two sharp changes to colder weather occurred, the falls from 8 a. m., December 31, to 8 a. m., January 1, ranging from 20° to 50° or more over a wide area from the Middle and East Gulf and South Atlantic States northward to the Ohio Valley and lower Lake region, the surface temperatures at the same time ranging from nearly 50° below zero in Montana to 60° above in southern Florida.

During the following day or two the anticyclone gradually extended southeastward, and temperatures continued to fall over the Gulf and South Atlantic States, the severest cold over portions of southern Florida occurring on the mornings of the 3d and 4th, at which times temperatures below freezing extended into and even south of the Everglades.

While the extreme low temperatures in Florida and near-by areas during this period were slightly higher than on some other occasions, still the effect of the cold was greatly augmented by the long periods during which the temperature continued constantly below the freezing point. In some instances this covered a greater number of hours than was the case during the severe cold of February, 1899.

Though unusual cold prevailed at this time over much of the far Northwest and in the more southern districts from the Great Plains eastward, the cold was not unusually severe over the northeastern districts.

A prompt rise in temperature followed the anticyclone referred to above, and moderate winter weather prevailed over most districts until the middle of the month, some unusually high temperatures for midwinter occurring in the lower Missouri and middle Mississippi Valleys about the 10th.

No important cyclone crossed the country during the first half of the month, though considerable precipitation occurred near the end of the first decade over the Southeastern and Atlantic Coast States, and about the 14th and 15th from the upper Mississippi Valley eastward to New England.

A sharp fall in temperature occurred over the more northern States from the Dakotas eastward on the 15th and 16th, but warmer weather quickly followed, continuing until the end of the second decade, when an important anticyclone again entered the Northwest and quickly overspread the country from the Rocky Mountains eastward, bringing sharp falls in temperature and carrying the frost line again into the coast districts of the East Gulf and South Atlantic States. Slightly preceding this cold wave a cyclone of moderate strength moved from the middle Plains to the upper Lake region and thence to the St. Lawrence Valley, causing during the 19th and 20th rather widespread, but mostly light precipitation from the Mississippi Valley eastward.

The early part of the third decade was without important weather changes, though on the 24th a well-defined cyclone was central near southern Missouri, which moved rapidly to the northeastward and was central on the morning of the 25th as a storm of considerable severity over northern New England. It was attended by widespread and moderately heavy precipitation from the Mississippi River eastward, mostly rain, though some snow occurred in the Ohio Valley and Great Lakes region.

An important anticyclone developed over the middle plateau on the morning of the 27th and gradually moved southeastward, reaching the vicinity of Florida on the morning of the 29th, when unusually low temperatures occurred over the southern portions of that State. While temperatures over the Southeastern States were mainly considerably higher at this time than occurred during the cold wave earlier in the month, yet in the more southern portions of Florida the minimum temperatures on the 29th in the districts to the southeast of Lake Okeechobee were from 3° to 5° or more lower than on the previous occasion. Concerning these conditions, the official in charge at Jacksonville states that some of the

fall in temperature was due to strong radiation rather than to the translation of cold from more northern locations.

While unusual cold existed over the Southeastern States as a result of the anticyclone covering that region about the 29th, temperatures in other portions of the country were not markedly low, and at the close moderate winter temperatures were again the rule.

The average pressure for the month was materially above normal over all southern, central, and northwestern districts, and below from the central Canadian Provinces southeastward and eastward to the Atlantic coast. These details, together with the changes in the average barometric pressures from December to January, are shown on the insets of Charts II and III.

The winds were mainly southerly from the Mississippi River eastward, from the south over the middle and southern Plains, and variable elsewhere. High winds were infrequent and damage therefrom was small save in the vicinities of Cincinnati, Ohio, and Louisville, Ky., where, on the 19th, tornadic winds caused material damage. The usual details concerning storms appear in the table at the end of this section.

TEMPERATURE

The average monthly temperatures were above normal over the entire United States and Canada also, as far as records disclose, save in small areas along the South Atlantic and Gulf coasts and locally at a few points elsewhere. In the central valleys and more northern districts the excesses ranged from 5° to 10°, and in the Canadian Northwest they were materially larger. It was also distinctly warm in the far Southwest, Los Angeles, Calif., reporting the month as the warmest January of record.

The warmest periods were mainly near the middle of the month, though in New England the warmest day was the 1st and in some portions of the plateau the 5th and 6th were the warmest.

The coldest period for most districts was near the 1st of the month, though in the plateau and portions of the Pacific Coast States the lowest temperatures occurred about the 17th to 19th, while in the upper Lake region and over the Middle Atlantic States the 29th and 30th were the coldest days.

Much damage to winter truck occurred in the Gulf and South Atlantic coast districts, and considerable damage to citrus fruits is reported in the eastern areas where these are grown.

PRECIPITATION

January was a notably dry month, and days with rain or snow were infrequent in nearly all portions. While in only a few localities were the monthly amounts less than have previously occurred in this month, yet the deficiency was probably the most general and widespread ever known. Among more than 200 regular Weather Bureau stations well distributed over the country reporting precipitation, less than 5 per cent had amounts in excess of the monthly normals. Like conditions prevailed over the adjoining portions of western Canada, but in the Maritime Provinces of that country there appears to have been a moderate but general excess.

Atmospheric pressure conditions were favorable for a dry month along the Pacific coast, though January is usually the month of maximum precipitation in this area. Due to the presence of anticyclonic conditions which prevailed over the plateau region no cyclones entered the United States from the Pacific coast during the entire first half of the month, and only occasionally during the latter half were conditions more favorable for such movement.

In other parts of the country there was a notable absence of the storms usual to winter, this being particularly the case over the Gulf and South Atlantic States, where generally the amounts of precipitation were only small percentages of the usual January falls.

SNOWFALL

While snow occurred as usual over the greater part of the country, the amounts were nearly everywhere much less than usually fall in the midwinter month, and in portions of the Central States in particular the depths of fall were among the least of record for January.

The most important snowstorm of the month, though limited to a small area, occurred on the 28th and 29th, when unusually heavy snow began during the early part of the 28th over the northeastern portions of Virginia and extended during the day into Maryland, eastern Pennsylvania, and New Jersey, with total falls ranging up to 30 inches in some north-central Maryland sections. During the following day the storm area extended northward to southern New England and westward into the lower Lakes and upper Ohio Valley, but with lessened severity. Over portions of the New Jersey coast the fall was the heaviest of record in any January.

In the western mountains the snowfall was mainly less than normal, and the amounts stored at the high elevations supplying some important irrigation and water-power projects were discouragingly small.

SEVERE LOCAL STORMS, JANUARY, 1928

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
West slope of Cascades and along Columbia River, Wash.	1-2					Glaze	Communication and power transmission wires damaged; trees broken.	Official, U. S. Weather Bureau.
Helena, Mont	11-12					High wind	Considerable damage to windows, light globes, etc.; roofs of several buildings torn off or ripped loose.	Do.
Cincinnati, Ohio and vicinity.[1]	19	7:07 a. m.	160		$100,000	Tornadic wind	Extensive property damage; 18 persons injured	Do.
Louisville, Ky.[1]	19	7:20-7:40 a. m.	50		[2] 94,000	Tornado	Damage confined to roofs, windows, and upper stories of buildings; a few buildings totally demolished; 18 [2] persons injured; path 16 miles long.	Do.
Peno, Okla	19	11:25 p. m.				Small tornado	2 residences wrecked; large seed house damaged	Southwest American (Fort Smith, Ark.).
Chattanooga, Tenn	19	10 a. m.				Wind and rain	Trees, autos, wires, etc., damaged	Official, U. S. Weather Bureau.
Fern Creek to Jeffersontown, Ky.	19				(2)	Tornado	Property damage reported over path 4 miles long	Do.
De Kalb, Kane, Du Page, and Cook Counties, Ill.	19-20					Wind	Rail and car service interrupted at points; trees, poles, and wires blown down; light farm buildings demolished; light service impaired.	Do.
Fond du Lac and Sheboygan Counties, Wis.	19-20				10,000	do	Character of damage not reported	Do.
Fort Wayne, Ind	19-20				2,000	do	Windows, telephone, and power lines damaged	Do.
Grand Haven, Mich	19-20					Wind and ice	Navigation tied up; school building partially unroofed; public utilities services interrupted.	Do.
Chattanooga, Tenn	24	1 p. m.			10,000	Wind and thunderstorm.	Old buildings, barns, etc., damaged; industrial plants suffer.	Do.
Cairo, Ill., and adjoining area of Kentucky.	24			1	10,000	Wind	Plate-glass windows, telephone lines, and roofs damaged; 1 person injured.	Do.
Chester, Rock Hill, and Columbia, S. C.	24	P. m.			8,000	Thunderstorm and wind.	Buildings and trees considerably damaged	Do.
Missouri (southeastern)	24					Wind	A number of dwellings damaged; trees broken; 5 persons injured.	Do.
Atlantic coast, New Jersey to Maine.	25				1,000,000	do	All forms of traffic and transportation interrupted; extensive damage to plate glass in New York City.	Evening World (New York City, N. Y.).

[1] For detailed description see p. 15 of this REVIEW.

[2] Figures of Louisville item include damage and injured at Fern Creek, Ky.

RIVERS AND FLOODS

By H. C. FRANKENFIELD

An ice gorge that formed in the Connecticut River at South Glastonbury, Conn., about January 6, caused a rather rapid rise in the river northward to Hartford, where a crest of 12.9 feet was reached at noon of January 8. Advices were issued on January 7, and on the following day the ice passed out without resulting damage.

There were no floods over the Atlantic drainage during the month, nor over the east Gulf drainage except a moderate one in the lower Tombigbee River of Alabama during the early days of the month. Warnings were first issued on January 1, and at 2:30 p. m. of January 5 the river at Lock No. 4, Demopolis, Ala., reached a stage of 43.4 feet, or 4.4 feet above the flood stage. The Black Warrior River crest was slightly below the flood stage. Only a very small area of the lowest bottoms near Demopolis was flooded, and losses were $3,900, with reported savings through warnings of $15,500.

Moderate local floods in the middle and lower Wabash River resulted from the rains of January 18, 19, and 24. Warnings were issued as required, and no damage was reported.

The Illinois River remained moderately high during the month, and the alluvial river was somewhat above flood stage throughout the month except at Peoria and Pearl, Ill. Only reassuring advices were necessary, and there was no damage.

In the lower Missouri River and the St. Louis section of the Mississippi River ice movements during the first half of the month created an interesting situation. Regarding this Mr. M. W. Hayes, of the Weather Bureau office at St. Louis, commented as follows:

In the lower Missouri and the Mississippi ice movement was of great interest. Heavy floating ice began on the 1st, and by the morning of the 4th a gorge had formed at Salt Lake Towhead, 43 miles south of St. Louis. Other gorges formed, which resulted in the river at St. Louis rising from 9 feet on the 3d to 21.6 feet on the 7th. Gorges between St. Louis and Salt Lake Towhead moved slightly and caused fluctuations in the St. Louis stage on the 8th, 9th, and 10th. The gorge at Salt Lake Towhead, and the others, began breaking up on the 10th, causing a rapid fall of 9.7 feet in the 48 hours ending at 7 a. m. of the 12th. The St. Louis Harbor was clear of ice on the 15th. Every effort was made to collect ice information for the benefit of bridge construction contractors on the lower Missouri and the Mississippi, and for managers of floating property. The efforts were reasonably successful.

The newly repaired Port Barre South Levee, west of the Atchafalaya River in the State of Louisiana, was breached about 2 miles south of Henderson, La., on December 21, 1927, and during the early days of January, 1928, gave way at several other near-by places. Seventeen farms were flooded and 70 partly flooded—about 2,000 acres in all. Movable property was not damaged, but Red Cross relief measures were extended to 33 families.

Unusually mild temperatures over the State of Montana during the first half of January caused a general and rapid reduction in snow cover, and also the breaking up of the ice on the Yellowstone River. On January 18 warnings were issued from the district center at Bismarck, N. Dak., to prepare for a 6-foot rise in the Missouri River at that place and decided rises at all points below. The rises occurred as forecast, and only more favorable weather prevented more serious conditions. At Glendive, Mont., on the Yellowstone River, the river, on January 14, reached a stage of 23.3 feet, or 6.3 feet above the flood stage, and some lands in the lower portion of the city were inundated.

Ice also broke in Milk River of Montana. Several gorges formed in the vicinity of Havre and there was some local flooding. West of the mountains rains, melting snows, and ice caused several floods in the smaller streams of northern Idaho, Washington, and Oregon, and there was much flooding of lowlands as well as serious interruption of railroad and highway traffic.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
East Gulf drainage					
	Feet			*Feet*	
Tombigbee: Lock No. 4, Demopolis, Ala.	39	2	8	43.4	Jan. 5.
Pearl: Jackson, Miss.	20	(1)	12	24.2	Jan. 7.
West Pearl: Pearl River, La.	13	3	11	14.1	Jan. 5, 6.
Mississippi drainage					
Tuscarawas: Gnadenhutten, Ohio	9	1	2	10.7	Jan. 1.
Wabash:					
Lafayette, Ind.	11	20	21	12.6	Jan. 21.
Covington, Ind.	16	21	21	16.1	Jan. 21.
Tippecanoe: Norwoy, Ind.	6	5	17	6.5	Jan. 11, 12.
		19	20	6.3	Jan. 20.
		25	26	6.0	Jan. 26.
Illinois:					
Morris, Ill.	13	5	7	[2] 13.7	Jan. 6.
Peru, Ill.	14	(1)	(3)	20.0	Dec. 18-19.
Henry, Ill.	10	(1)	(3)	14.4	Dec. 17-18.
Peoria, Ill.	18	(1)	2	20.9	Dec. 18-20.
Havana, Ill.	14	(1)	(3)	18.1	Dec. 19.
Beardstown, Ill.	14	(1)	(3)	19.3	Dec. 16-18.
Pearl, Ill.	12	(1)	5	15.8	Dec. 20.
		14	29	13.0	Jan. 19, 22.
Petit Jean: Danville, Ark.	20	19	21	21.8	Jan. 20.
Black:					
Corning, Ark.	11	1	1	11.0	Jan. 1.
		21	30	11.7	Jan. 25.
Black Rock, Ark.	14	(1)	1	25.3	Dec. 15.
Cache: Patterson, Ark.	9	25	28	9.6	Jan. 27.
West Gulf drainage					
Trinity: Trinidad, Tex.	28	1	4	29.1	Jan. 2, 3.
Pacific drainage					
Willamette: Harrisburg, Oreg.	7	2	8	9.5	Jan. 2.
		14	15	9.8	Jan. 14.

[1] Continued from last month.
[2] Ice reading.
[3] Continued at end of month.

MEAN LAKE LEVELS DURING JANUARY, 1928

By UNITED STATES LAKE SURVEY

[Detroit, Mich., February 3, 1928]

The following data are reported in the Notice to Mariners of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during January, 1928:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	602.18	578.72	571.26	246.04
Above or below—				
Mean stage of December, 1927	−0.14	−0.06	−0.35	+0.39
Mean stage of January, 1927	+0.74	+0.52	+0.15	+0.76
Average stage for January, last 10 years	+0.57	−0.50	−0.04	+0.96
Highest recorded January stage	−0.60	−3.95	−2.29	−1.56
Lowest recorded January stage	+1.73	+1.34	+1.22	+2.24
Average departure (since 1860) of the January level from the December level	−0.25	−0.11	−0.07	−0.02

[1] Lake St. Clair's level: In January, 1928, 574.04 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, JANUARY, 1928

By J. B. KINCER

General summary.—The outstanding features of the weather for January, 1928, as affecting farming operations, and particularly winter crops, were the cold wave of unusual severity which overspread the Southeast at the beginning of the month, and the persistent drought in the Southwest, extending from western Nebraska and eastern Colorado southward. The cold wave caused heavy damage to winter truck crops in coast sections from Texas to southeastern Virginia, with all but the hardier varieties killed in the extreme Southeast, except in limited areas. Citrus fruits were also damaged considerably, although old groves escaped serious harm, as a rule. In the Southwest very little precipitation occurred, and winter grain crops were badly in need of moisture over a considerable area.

Following the freeze in the South, showers and much warmer weather were favorable in reviving hardy truck that had been previously damaged, and the mild, open weather permitted active field operations throughout the second decade. In the interior States, however, continued absence of snow cover was unfavorable for grass and grain crops in many sections. The last decade had generally warm weather for the season over the western half of the country and low temperatures in the East, and outdoor operations made better advance in the former, and less progress in the latter districts. The sharp freeze the latter part of the period in Southeastern States did no great amount of harm, except along the southeast Florida coast where some crops, particularly tomatoes, were damaged or killed.

Small grains.—Early in the month unseasonably warm weather in the interior States removed the snow cover from important grain areas and left fields generally bare over the principal wheat-producing sections east of the Rocky Mountains. Thereafter, there was but little snow protection, and the rather frequent alternate thawing and freezing were unfavorable for the wheat crop over the eastern half of the belt. In the western portion conditions were more favorable, aside from the need of moisture in parts of the upper Mississippi Valley, in Nebraska, and from western Kansas southward. In the lower Missouri Valley, including eastern Kansas, the moisture from melting snows was favorable and winter grains continued in apparently good condition in most districts. In the far Northwestern States, including Montana, Idaho, Oregon, and Washington, conditions continued generally favorable for winter grains, with fields mostly well protected by snow. In the South, winter oats suffered severely from the freeze early in the month, and reports thereafter were generally unfavorable.

Miscellaneous crops.—In the Ohio Valley, the absence of snow, with alternate freezing and thawing, was unfavorable for meadows. In the Southwest, continued dryness unfavorably affected the range, but in most other portions of the great western grazing districts conditions were favorable, while the generally mild, open weather permitted much grazing in the northern Great Plains. Livestock continued in fair to good condition in most

Western States, with early lambing in the north Pacific area advanced at the close of the month.

Following the damage to truck crops in the Southern States early in the period, the weather was generally favorable and replanting was active. In Florida showers were very beneficial the latter part of the month, but moisture was deficient in that State during most of the time. There was much defoliation of citrus trees, and unprotected groves suffered considerable injury in parts of California by cold weather the last half of the month. Sharp cold periods, however, in Southern States were favorable in retarding the unseasonable advance of fruit buds, and deciduous trees were apparently in good condition at its close.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

As shown on the Pilot Chart, January is normally the stormiest month of the year over the North Atlantic, and during the current month the number of days with gales was equal to, if not in excess of, the normal over the greater part of the steamer lanes. In the 5° square between the forty-fifth and fiftieth parallels and the thirty-fifth and fortieth meridians gales were reported on 11 days, and at times the storm area extended as far south as the thirty-fifth parallel, accompanied by comparatively high barometric readings.

It will be remembered that December was also an unusually stormy month, but the conditions were materially different from those of January. In December there were long periods of low pressure over the area usually occupied by the North Atlantic HIGH, while at the same time anticyclonic conditions prevailed in the vicinity of Iceland. In January, on the contrary, both the North Atlantic HIGH and Icelandic LOW were unusually well developed, as indicated by the large plus and minus pressure departures at Horta and Lerwick, respectively, as shown in Table 1. In both months gales of force 11 and 12 were not uncommon, but in December the usual "westerlies" were often replaced by easterly winds.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (75th meridian), North Atlantic Ocean, January, 1928*

Stations	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Belle Island, Newfoundland	29.59	−0.21	30.20	4th [2]	28.47	26th.
Halifax	29.88	−0.12	30.38	16th [2]	29.24	21st.
Nantucket	29.93	−0.16	30.56	16th	29.08	25th.
Hatteras	30.14	+0.01	30.56	6th	29.76	20th.
Key West	30.17	+0.08	30.38	6th [2]	30.00	19th.
New Orleans	30.11	+0.16	30.60	3d [2]	29.88	19th.
Cape Gracias	29.99	+0.04	30.10	29th	29.90	31st.
Turks Island	30.14	+0.09	30.28	6th	30.10	1st.[2]
Bermuda	30.13	+0.08	30.50	6th	29.84	11th.
Horta, Azores	30.41	+0.31	30.76	5th [2]	29.86	17th.
Lerwick, Shetland Islands	29.38	−0.32	30.06	1st	28.77	10th.
Valencia, Ireland	29.83	−0.07	30.35	5th	29.38	15th.
London	29.89	−0.11	30.37	1st	29.47	16th.

[1] From normals shown on H. O. Pilot Chart based on observations at Greenwich mean noon, or 7 a. m. 75th meridian time.

[2] And on other dates.

The number of days with fog was less than usual over the Grand Banks and steamer lanes, about normal off the American coast between Hatteras and Nantucket, and considerably above in the Gulf of Mexico, where it was reported on seven days.

On the 1st and 2d cyclonic conditions existed off both the American and European coasts. From the 3d to 5th comparatively moderate weather prevailed over the ocean as a whole, being the only period during the month in which a cyclonic disturbance did not occur, although on the 9th the gales were limited to a restricted area between the fifteenth and twentieth meridians.

From the 6th to 8th the middle section of the steamer lanes was swept by westerly gales, and from the 10th to 15th the same conditions prevailed in the eastern section.

On the 16th an exceptionally severe disturbance was central near 50° N., 35° W., with winds of hurricane force reported by vessels near the center.

From the 18th to 20th the greater part of the steamer lanes was storm swept, and on the latter date westerly gales also prevailed over the region north of the Bermudas, west of the sixtieth meridian.

On the 26th there was a heavy storm in the Mediterranean, as shown by storm report in table from the Am. M. S. *William Penn.*

Charts VIII to XIII cover the period from the 21st to 26th inclusive and give an idea of the extremely turbulent conditions which existed at that time.

On the 27th and 28th heavy weather still prevailed in midocean, although the storm area had contracted somewhat since the 26th.

On the 27th a "norther" was reported from the western section of the Gulf of Mexico.

On the 28th Hatteras was near the center of a LOW and moderate northwest gales prevailed along the east coast of Florida. This disturbance moved slowly northeastward, increasing in intensity, and by the 30th was over Newfoundland.

On the 31st a depression over the eastern section of the steamer lanes was responsible for moderate to strong westerly gales between the thirty-fifth meridian and European coast.

OCEAN GALES AND STORMS, JANUARY, 1928

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
North Atlantic Ocean			° ′	° ′				Inches					
American Shipper, Am. S. S.	London	New York	40 52 N.	67 47 W.	Jan. 1	Noon, 1	Jan. 2	29.40	SSW	SSW	W	W., 9	SSW.-W.
John W. Mackay, Br. S. S.	Halifax	Cable operations.	49 56 N.	39 20 W.	Jan. 6	8 a., 6	Jan. 8	29.40	SW	SW., 6	W	SW., 10	SW.-W.
Stockholm, Swed. S. S.	Gothenburg	New York	58 18 N.	10 36 W.	Jan. 7	11 p., 7	Jan. 8	28.80	W	WSW., 9	W	W., 11	SW.-W.
City of Flint, Am. S. S.	Boston	London	48 51 N.	35 00 W.	Jan. 11	10 a., 11	Jan. 11	29.10	SW	SW., 10	SW	—, 10	Steady.
Rockaway Park, Am. S. S.	Liverpool	Boston	46 30 N.	30 20 W.	Jan. 13	Noon, 13	Jan. 14	29.42	SSW	SSW., 8	WNW	WSW., 12	SSW.-WSW.
Breedijk, Du. S. S.	Galveston	Rotterdam	45 15 N.	40 44 W.	Jan. 15	6 a., 16	Jan. 16	28.85	S	WNW., 11	NW	WNW., 12	S.-NW.
Inkum, Br. S. S.	Newport News.	Liverpool	48 28 N.	32 08 W.	Jan. 16	1 p., 16	Jan. 16	29.13	S	S	WSW	S., 12	
Ampetco, Belg. S. S.	Baton Rouge	Rotterdam	39 48 N.	58 37 W.	Jan. 17	2 p., 17	Jan. 20	29.37	SW	W., 10	Var.	WNW., 12	SW.-WNW.
Rockaway Park, Am. S. S.	Liverpool	Boston	45 43 N.	37 42 W.	Jan. 16	Noon, 18	Jan. 23	28.96	S	W., 10	WNW	—, 12	SSW.-W.
Mercian Br. S. S.	Manchester	New York	50 01 N.	26 42 W.	Jan. 18	1 p., 19	Jan. 20	28.71	SSE	SW	W	—, 12	S.-WSW.
Balsam, Am. S.S.	Glasgow	Baltimore	45 10 N.	21 29 W.	Jan. 16	8 a., 19	Jan. 20	29.36	S	SSW., 11	NW	SSW., 11	
William Penn, Am. M. S.	Karachi, India.	New York	37 20 N.	10 16 E.	Jan. 20	2 p., 20	Jan. 21	30.10	NW	NW., 9	NW	NW., 12	
Casper, Am. S. S.	Sarpsborg, Norway.	Portland, Me.	51 32 N.	43 18 W.	Jan. 22	8 a., 22	Jan. 28	28.93	WNW	WNW., 9	NW	NW., 12	Steady.
Ampetco, Belg. S. S.	Baton Rouge	Rotterdam	47 35 N.	30 54 W.	Jan. 22	Noon, 23	Jan. 26	29.81	WNW	WNW., 9	WNW	WNW., 12	Do.
Thuringia, Ger. S. S.	Cobh	Boston	49 57 N.	25 41 W.	Jan. 24	Mdt., 24	Jan. 25	29.74	SW	SW., 11	WSW	—, 12	
Providence Fr. S. S.	Lisbon	New York	39 23 N.	64 36 W.	Jan. 24	9 a., 25	Jan. 26	29.61	SE	S., 10	W	S., 10	S.-SSW.
Arkansas, Dan. S. S.	South Shields	Baltimore	56 15 N.	24 00 W.	Jan. 23	1 a., 25	Jan. 26	28.66	WSW	SSW., 11	NW	NW., 12	SW.-NW.
Reliance, Ger. S. S.	New York	San Juan	39 30 N.	73 30 W.	Jan. 25	4 p., 25	Jan. 26	29.63	WNW	WNW., 11	W	WNW., 11	Steady.
Hellig Olav, Dan. S. S.	Oslo	New York	52 40 N.	41 25 W.	Jan. 26	4 p., 26	Jan. 28	29.18	SSE	SW., 7	W	WSW., 11	SSE.-SW.
Monterey, Am. S. S.	New York	Tampico	19 24 N.	95 42 W.	Jan. 27	5 a., 27	Jan. 28	30.11	N	N., 6	N	N., 8	Steady.
Thuringia, Ger. S. S.	Cobh	Boston	47 30 N.	34 45 W.	Jan. 26	4 a., 27	Jan. 27	29.94	SSW	SSW., 10	SSW	—, 11	Do.
Cabo Espartel, Span S.S.	Malaga	New York	34 22 N.	68 05 W.	Jan. 27	4 a., 28	Jan. 30	29.56	WSW	WSW., 10	WNW	—, 10	
Balsam, Am. S. S.	Glasgow	Baltimore	38 54 N.	61 00 W.	Jan. 27	5 p., 29	Jan. 30	29.52	SW	SW., 12	NNW	SW., 12	
Trinculo, Br. S. S.	Curacao	Avonmouth	46 00 N.	15 03 W.	Jan. 28	Mdt., 29	Jan. 29	29.81	SW	NW	ESE	NW., 10	NW.-WNW.
Columbus, Ger. S. S.	Cherbourg	New York	48 18 N.	32 13 W.	Jan. 30	Mdt., 30	Jan. 31	29.68	SW	WSW., 7	NNW	WSW., 10	Steady.
Atlanta City, Am. S. S.	Port Said	Gibraltar	36 20 N.	3 15 W.	Jan. 30	1 a., 30	Jan. 30	29.65	NNW	NNW., 8	NNW	NNW., 9	SW.-S.-NNW.
Arkansas, Dan. S. S.	South Shields	Baltimore	50 20 N.	35 08 W.	Jan. 30	1 a., 31	Feb. 1	29.45	SW	SW., 12	NW	—, 12	WSW.-NW.
Lorain, Am. S. S.	Hamburg	do	37 — N.	62 — W.	Jan. 31	1 p., 31	Jan. 31	30.26	WSW	WSW., 9	NW	NNW., 9	SW.-W.
North Pacific Ocean													
Aorangi, Br. M. S.	Honolulu	Victoria	31 40 N.	148 26 W.	Jan. 1	3 a., 2	Jan. 4	29.33	SW	W., 6	S	S., 10	W.-WSW.
Stanley, Am. S. S.	Pulupandan	San Pedro	34 00 N.	160 20 W.	1	2 p., 1	4	29.18	NNW	WNW., 7	W	W., 10	NNE.-WNW.
Malolo, Am. S. S.	San Francisco.	Honolulu	31 16 N.	140 07 W.	2	Noon, 2	3	29.74	SW	WSW., 9	WNW	WSW., 9	SW., 3-WSW.
Havre Maru, Jap. S. S.	Los Angeles	Yokohama	32 34 N.	144 55 E.	2	9 p., 2	3	29.48	SSW	WSW., 9	W	W., 9	SSW.-W.
West Niger, Am. S. S.	Columbia River.	do	41 00 N.	150 00 E.	2	Mdt., 3	4	29.10	SE	WNW., 6	NW	NW., 12	SE.-WNW.
Atlantic Maru, Jap. S. S.	Kobe	San Francisco.	43 10 N.	141 16 W.	3	Noon, 3	4	28.84		S., 9		SW., 10	S.-SW.
Paris Maru, Jap. S. S.	Vancouver	Yokohama	42 20 N.	148 20 E.	3	2 p., 3	4	28.61	W	W., 11	NW	W., 11	W.-NW.
Tamaha, Br. S. S.	Shanghai	San Pedro	40 06 N.	176 10 E.	3	5 p., 5	7	29.12	SSE	NW., 8	NW	WNW., 10	W.-NNW.
Bohemian Club, Am. S. S.	Balboa	do	15 34 N.	98 44 W.	5	6 p., 5	6	29.94	N	N	N	N., 10	Steady.
Makiki, Am. S. S.	Seattle	Honolulu	36 44 N.	143 16 W.	6	4 p., 6	6	29.50	SSW	S., 8	SW	SW., 9	
Silvercedar, Br. M. S.	Manila	San Francisco.	34 58 N.	162 23 W.	6	4 a., 7	7	29.31	NW	W	WNW	W., 9	NW.-W.
Robin Adair, Am. S. S.	Balboa	San Pedro	16 00 N.	94 40 W.	6	2 a., 7	7	30.10	N	NNW., 10	NE	NNW., 10	N.-NNW.
Bessemer City, Am. S. S.	Los Angeles	Yokohama	30 20 N.	146 50 E.	7	4 a., 8	9	29.87	NW	NW., 8	NNE	NW., 9	
Kohshun Maru, Jap. S. S	Miike	Coos Bay	48 23 N.	168 15 W.	8	Mdt., 8	9	28.59	E	NE., 10	N	NE., 10	NE.-N.
Akagisan Maru, Jap. S. S.	Yokohama	San Francisco.	46 50 N.	155 09 W.	9	Noon, 9	11	28.57	SSE	SSW., 9	WSW	SSE., 10	SSE.-WSW.
Meiyo Maru, Jap. S. S.	Vancouver	Yokohama	41 43 N.	147 23 E.	11	8 p., 11	13	29.54	W	WNW., 2	NW	W., 9	
Tahchee, Br. S. S.	Cebu	San Pedro	39 40 N.	165 54 W.	16	8 p., 17	17	29.70	S	S., 10	SSW	S., 10	S.-SSW.
Emp. of Russia, Br. S. S.	Yokohama	Victoria	49 43 N.	170 35 W.	17	4 a., 18	18	29.38	NW	WNW., 8	W	WNW., 9	WNW.-W.
Do	do	do	50 11 N.	142 47 W.	20	3 p., 20	20	29.51	N	N., 9	N	N., 9	Steady.
Las Vegas, Am. S. S.	Kobe	Portland	46 05 N.	164 15 E.	19		20	28.46	ENE	NNE., 4	ENE	ENE., 11	
Tacoma, Br. S. S.	Yokohama	San Francisco.	40 00 N.	153 15 E.	18	4 a., 19	21	29.02	ESE	W., 9	NW	W., 9	ESE.-WSW.
Grace Dollar, Am. S. S.	Manila	do	31 18 N.	144 51 E.	20	8 a., 20	21	30.08	NW	NW., 8	NNW	NW., 9	Steady.
Do	do	do	34 16 N.	168 00 E.	26	2 a., 26	26	29.93	S	S., 7	SSW	S., 9	Do.
Edenton, Am. S. S.	Pulupandan	Honolulu	16 40 N.	145 45 E.	20	4 p., 21	24	29.83	NE	NE., 7	ENE	NE., 8	NE.-E.
Lio, Am. M. S.	San Francisco.	Balboa	15 33 N.	94 40 W.	22	2 p., 22	22	29.95	NE	NNE	NE	NE., 10	NE.-NNE.
Makaweli, Am. S. S.	Bellingham	Hilo	36 21 N.	141 11 W.	27	Mdt., 27	28	29.78	NNE	NNE., 7	NE	N., 9	NE.-N.
Jadden, Am. S. S.	San Pedro	New Orleans	14 50 N.	96 20 W.	28	4 p., 28	29	29.84	E	ENE	N	NNE., 10	E.-NE.-N.
Archer, Am. S. S.	Pulupandan	San Pedro	41 08 N.	152 49 E.	28	11 a., 29	31	29.13	NE	NE., 7	W	NW., 9	

NORTH PACIFIC OCEAN

By Willis E. Hurd

The year 1928 opened with cyclonic weather, accompanied by widespread gales which frequently attained force 10, prevailing over the greater part of the ocean east of the one hundred and eightieth meridian. At this time the only persisting remnants of anticyclones at sea in west longitudes were found off the coast of southern California and at the northern extremity of the Gulf of Alaska. However, this great low pressure area soon began to slowly contract northward, until by the 12th a practically normal barometric condition prevailed, the cyclone now lying over and somewhat to the southward of Aleutian waters; the east Pacific anticyclone in good strength occupying the central part of the ocean; thereafter it remained quite stable until toward the end of January, when a cyclone of some energy moved into its region from the north and disturbed the weather along the east-central part of the upper California-Hawaii routes from the 27th to the 31st.

Pressure over northern waters was considerably below the normal, while along the American coast south of Alaska, and in mid-ocean below the thirtieth parallel, it was above normal. See following table of barometric data:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, January, 1928*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Dutch Harbor [1]	29.35	−0.29	29.86	26th	28.18	6th.
St. Paul [1] [2]	29.37	−0.32	29.82	25th	28.90	13th.[5]
Kodiak [1]	29.45	−0.10	30.10	1st	28.40	7th.
Midway Island [1]	30.09	+0.09	30.40	11th	29.80	8th.[5]
Honolulu [3]	30.09	+0.09	30.21	22d	29.89	1st.
Juneau [3]	29.84	−0.04	30.46	18th	28.78	7th.
Tatoosh Island [3] [4]	30.10	+0.16	30.44	26th	29.67	21st.
San Francisco [3] [4]	30.23	+0.14	30.45	7th	29.90	14th.
San Diego [3] [4]	30.13	+0.07	30.31	17th	29.79	14th.

[1] P. m. observations only.
[2] For 30 days.
[3] A. m. and p. m. observations.
[4] Corrected to 24-hour mean.
[5] And other dates.

January, however, was less stormy than either of the two preceding months. Yet moderate to strong gales were experienced over most of the upper two-thirds of the ocean during the first few days, though they did not attain to hurricane force except on the 3d, between 40° N., 150° E., and the upper Japanese coast. After the 7th, although moderate scattered gales continued, there was a general diminution of high windiness until after mid month, then a gradual increase over large sections of the ocean, the maximum known wind of this latter period being of force 11 near 46° N., 164° E., on the 21st. Local gales of forces 8 and 9 occurred during the last five days of the month in connection with the cyclone which hung off the California coast. This disturbance, the most peculiar of the month, moved about in all directions, expanding and contracting, while hemmed in by anticyclones except on its northwestern quadrant, where it connected with the northern LOW.

At Honolulu the prevailing wind direction continued from the east, average velocity, 10.5 miles, maximum velocity, 31 miles, from the east.

This January was reported as one of the warmest on record off the coast of southeastern Alaska.

Northers were exceptionally frequent and severe in the Gulf of Tehuantepec. Gales equaling or exceeding force 8 occurred on about 30 per cent of the days, attaining force 10 on four occasions. The winds thence down the Central American coast were also unusually strong, reaching force 7 on several days.

Fog was of very slight occurrence over by far the greater area of the ocean, except adjacent to the American coast. Nine days with fog were reported off Lower California, and it was observed on 14 days between the thirtieth and fortieth parallels, from the coast to longitude 132° W. Some 20 per cent of fog formed along the coastwise routes between latitudes 40° and 50° N., with slightly the greatest frequency experienced about Vancouver Island.

CLIMATOLOGICAL TABLES

DESCRIPTION OF TABLES AND CHARTS

Table 1 gives the data ordinarily needed for climatological studies for about 176 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m. daily, seventy-fifth meridian time, and for about 37 others making only one observation. The altitudes of the instruments above ground are also given.

Beginning January 1, 1928, movement and velocity of the wind are printed as recorded by the three-cup anemometer replacing the four-cup pattern.

Table 2 gives, for about 35 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation, depth of snowfall and the respective departures from normal values except in the case of snowfall. The sea-level pressures have been computed according to the method described by Prof. F. H. Bigelow in the REVIEW of January, 1902, **30:** 13–16.

CHART I.—*Temperature departures.*—This chart presents the departures of the monthly mean surface temperatures from the monthly normals. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly surface temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909, but smaller charts appear in W. B. Bulletin U from 1873 to June, 1909, inclusive.

CHART II.—*Tracks of centers* of ANTICYCLONES; and

CHART III.—*Tracks of centers* of CYCLONES. The Roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., seventy-fifth meridian time. Within each circle is also given (Chart II), the last three figures of the highest barometric reading, or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity. The inset map of Chart II shows the departure of monthly mean pressure from normal and the inset of Chart III shows the change in mean pressure from the preceding month.

CHART IV.—*Percentage of clear sky between sunrise and sunset.*—The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

CHART V.—*Total precipitation.*—The scales of shading with appropriate lines show the distribution of the monthly precipitation. The inset on this chart shows the departure of the monthly totals from the corresponding normals.

CHART VI.—*Isobars at sea level, average surface temperatures, and prevailing wind directions.*—The pressures have been reduced to sea-level and standard gravity by the method described by Prof. Frank H. Bigelow in the REVIEW for January, 1902, **30**:13–16. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The sea-level temperatures are now omitted and average surface temperatures substituted. The isotherms can not be drawn in such detail as might be desired, for data from only the regular Weather Bureau stations are used.

The prevailing wind directions are determined from hourly observations at the great majority of the stations.

A few stations determine their prevailing directions from the daily or twice-daily observations only.

CHART VII.—*Total snowfall.*—This is based on the reports from regular and cooperative observers and shows the depth in inches of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures also are given. This chart is published only when the snowfall is sufficiently extensive to justify its preparation. The inset of this chart, when included, shows the depth of snow on the ground at the end of the month.

CHARTS VIII, IX, etc.—*North Atlantic Weather maps of particular days.*

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation, by sections, January, 1928

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	44.9	−1.0	Eufaula	81	16	Valley Head	−2	2	1.56	−3.50	Maple Grove	3.34	Alaga	0.25
Arizona	45.4	+1.7	3 stations	83	[1] 6	2 stations	−7	[1] 17	0.18	−1.06	Childs	1.50	49 stations	0.00
Arkansas	42.7	+1.6	Dumas	90	11	Lead Hill	−10	3	2.05	−2.05	Higden	4.00	Whitecliffs	0.50
California	46.3	+1.0	2 stations	92	12	Helm Creek	−24	18	1.84	−3.60	Cummings	12.59	10 stations	0.00
Colorado	28.4	+4.4	Lamar	82	14	Sunbeam	−34	1	0.27	−0.73	Steamboat Springs	1.53	15 stations	0.00
Florida	56.0	−2.7	2 stations	87	[1] 16	4 stations	15	[1] 2	0.75	−2.02	Blountstown	1.78	Everglades	0.02
Georgia	46.0	−0.6	2 stations	83	[1] 15	Blue Ridge	−5	2	1.46	−2.78	Cornelia	3.38	Waycross	0.36
Idaho	25.9	+1.8	4 stations	57	[1] 5	Stanley	−29	17	1.90	−0.19	Avery	5.77	Dubois	T.
Illinois	29.1	+2.3	Harrisburg	74	16	2 stations	−19	2	1.08	−1.18	Danville	2.69	Astoria	0.05
Indiana	29.0	+0.4	2 stations	73	16	2 stations	−15	2	1.74	−1.31	Butlerville	2.86	Whiting	0.45
Iowa	26.2	+6.6	Little Sioux	70	10	2 stations	−20	2	0.17	−0.90	Olin	1.04	10 stations	T.
Kansas	34.7	+4.9	6 stations	80	14	Burr Oak	−22	3	0.09	−0.57	Toronto	0.59	9 stations	0.00
Kentucky	35.0	−0.5	Williamsburg	76	15	Junction City	−8	2	2.47	−1.91	Jenkins	4.24	Ravenna	0.90
Louisiana	50.6	−0.6	2 stations	85	[1] 11	Plain Dealing	9	2	1.03	−3.70	Paradis	2.87	Newllano	0.00
Maryland-Delaware	34.3	+1.7	2 stations	72	15	2 stations	−11	30	2.52	−0.85	Maryland Line, Md.	4.65	Hancock, Md.	0.71
Michigan	23.0	+3.1	Eau Claire	60	15	Humboldt	−32	30	1.83	+0.03	Calumet	6.56	Kent City	0.42
Minnesota	12.9	+4.6	Winona	51	6	2 stations	−39	2	0.36	−0.38	Farmington	1.15	Willmar	0.05
Mississippi	46.7	−0.2	Rosedale	83	11	3 stations	3	3	1.72	−3.42	Grenada	3.49	Columbia	0.61
Missouri	33.3	+2.9	Poplar Bluff	77	11	Louisiana	−18	2	0.87	−1.16	Doniphan	2.26	8 stations	T.
Montana	22.3	+3.9	Winifred	64	12	Big Sandy	−48	1	0.98	+0.24	Hebgen Dam	3.39	Savage	0.00
Nebraska	29.1	+7.2	Culbertson	73	13	Gordon	−26	1	0.16	−0.39	Hay Springs	0.80	Ericson	0.00
Nevada	32.0	+2.0	Beatty	73	12	Millett	−16	18	0.38	−0.61	Tuscarora	1.21	3 stations	0.00
New England	24.4	+2.0	2 stations	58	1	Pittsburg (a), N. H.	−37	16	2.74	−0.67	Somerset, Vt.	4.81	Waterbury, Conn.	1.02
New Jersey	32.5	+2.6	3 stations	65	15	Layton	−15	30	2.26	−1.35	Chatham	3.97	Sandy Hook	1.37
New Mexico	35.8	+2.1	2 stations	62	[1] 11	Dulce	−18	1	0.02	−0.50	Red River Canyon	0.35	112 stations	0.00
New York														
North Carolina	41.0	−0.6	Goldsboro	85	16	Banners Elk	−13	2	1.57	−2.33	Parker	5.06	Manteo	0.22
North Dakota	13.0	+8.1	2 stations	50	[1] 11	2 stations	−41	[1] 1	0.21	−0.33	Cando	1.04	2 stations	0.00
Ohio	29.1	+0.9	2 stations	71	[1] 14	2 stations	−10	3	1.70	−1.31	Bangorville	2.88	Catawba Island	0.87
Oklahoma	41.4	+3.1	Hollis	85	14	Boise City	−8	1	0.95	−0.53	McAllester	3.32	2 stations	0.00
Oregon	34.8	+0.7	McMinnville	69	11	La Grande	−8	1	4.07	−0.65	Valsetz	17.74	Andrews	0.26
Pennsylvania	29.8	+2.0	3 stations	65	[1] 8	Gouldsboro	−23	30	2.08	−1.25	York Haven	4.48	2 stations	0.78
South Carolina	44.7	−0.8	Summerville	81	17	Caesar's Head	0	2	1.48	−2.06	Walhalla	3.20	Rimini	0.10
South Dakota	20.8	+4.9	Hermosa	70	10	Camp Crook	−37	1	0.21	−0.39	Hardy Ranger Station	1.50	3 stations	0.00
Tennessee	38.6	−0.1	Lynnville	77	16	4 stations	−10	2	2.90	−1.84	Cedar Hill	4.53	Buffalo Valley	0.90
Texas	48.7	+0.2	Fort Stockton	93	15	Dalhart	−7	1	0.67	−1.16	Encinal	3.40	18 stations	0.00
Utah	27.6	+2.3	2 stations	68	[1] 13	Castle Rock	−16	[1] 19	0.42	−0.92	Silver Lake	1.31	4 stations	0.00
Virginia	37.4	+1.8	Diamond Springs	79	15	2 stations	−5	2	2.17	−1.26	Callaville	3.54	Culpeper	1.10
Washington	31.6	+1.5	3 stations	62	[1] 9	Newport (a)	−12	1	5.31	−0.23	Wynooche Oxbow	28.06	Hassan	0.69
West Virginia	32.0	−0.1	New Martinsville	74	17	Pickens	−14	29	2.18	−1.75	Pickens	4.55	Moorefield	0.12
Wisconsin	17.8	+3.8	Racine	56	14	Rest Lake	−40	28	0.48	−0.80	Flambeau Reservoir	1.54	Hillsboro	0.08
Wyoming	23.6	+4.1	Fort Laramie (near)	71	12	2 stations	−34	1	0.69	−0.11	Crandall Creek	3.36	Pinebluff	0.01
Alaska (*December*)	16.8	−0.1	Dutch Harbor	52	8	Fort Yukon	−50	28	5.15	−0.62	Latouche	17.40	Fort Yukon	0.20
Hawaii	68.9	+0.9	Niulii	92	15	Glenwood	43	[1] 1	5.86	−3.42	Puu Kukui (upper)	33.00	3 stations	0.00
Porto Rico														

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, January, 1928*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind (3-cup anemometer used): Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							28.4	+3.9										71	2.27	−1.1										5.6		
Eastport	76	67	85	29.75	29.84	−0.16	22.8	+2.4	49	1	31	−7	21	15	31	21	15	70	3.18	−0.7	17	8,877	w.	45	se.	25	5	9	17	6.7	15.6	5.0
Greenville, Me.	1,070	6		28.63	29.84		14.0		43	25	23	−14	22	5	31				4.01		11		nw.				11	6	14		22.5	
Portland, Me.	103	82	117	29.78	29.91	−.14	26.2	+3.8	49	8	33	−2	22	19	29	23	16	67	2.83	−1.1	12	6,994	w.	40	s.	25	11	8	12	5.2	13.3	1.2
Concord	289	70	79	29.55	29.88	−.17	25.0	+3.4	51	7	33	−9	22	17	35				1.80	−1.2	9	4,843	w.	34	w.	25	12	11	8	4.9	9.8	1.0
Burlington	403	11	48	29.44	29.90	−.15	21.6	+2.8	45	1	29	−7	21	14	38				1.72	0.0	14	8,320	s.	32	s.	23	2	6	23	8.6	6.9	1.1
Northfield	876	12	60	28.93	29.91	−.14	19.6	+4.4	45	1	30	−14	22	10	46	18	15	82	2.26	−0.2	14	5,541	sw.	33	sw.	25	6	8	17	7.8	13.0	5.0
Boston	125	115	188	29.79	29.93	−.12	33.0	+5.1	58	1	40	11	30	26	38	28	21	64	1.66	−2.0	11	8,082	sw.	45	sw.	25	10	9	12	5.2	5.1	2.3
Nantucket	12	14	90	29.93	29.94	−.10	34.2	+2.9	53	8	40	14	30	28	25	31	26	77	3.22	−0.2	12	13,864	w.	54	sw.	25	10	7	14	5.7	5.4	4.0
Block Island	26	11	46	29.91	29.94	−.13	34.6	+3.6	54	1	40	14	29	29	32	31	26	73	1.85	−1.9	9	15,703	w.	58	sw.	25	9	14	8	5.3	1.5	1.2
Providence	160	215	251	29.77	29.95	−.11	32.4	+5.2	57	1	40	10	30	25	38	28	21	63	2.27	−1.4	12	8,634	nw.	48	s.	25	16	8	7	4.0	2.7	1.9
Hartford	159	122		29.80	29.99	−.08	31.2	+5.7	56	7	38	6	30	24	36				2.29	−1.6	10		sw.				13	12	6	4.4	4.8	2.7
New Haven	106	74	153	29.87	29.99	−.09	32.3	+4.1	55	7	40	10	30	25	37	28	22	69	1.92	−2.1	8	7,215	sw.	39	sw.	25	12	15	4	4.4	2.7	1.8
Middle Atlantic States							34.6	+2.5										67	2.08	−1.1										5.1		
Albany	97	102	115	29.86	29.97	−.10	28.8	+5.7	51	7	36	−1	30	22	31	25	20	74	1.78	−0.6	10	4,962	s.	26	s.	16	9	8	14	6.2	5.5	2.0
Binghamton	871	10	84	29.00	29.96	−.12	28.6	+4.5	52	15	36	3	27	22	32				1.48	−0.5	11	5,511	w.	31	w.	25	4	11	16	7.1	2.8	1.0
New York	314	414	454	29.66	30.02	−.08	33.8	+2.9	55	7	41	11	2	26	34	28	21	61	1.41	−2.2	9	14,712	w.	72	w.	25	8	15	8	5.4	3.0	1.4
Harrisburg	374	94	104	29.65	30.06	−.04	32.5	+3.5	60	13	40	6	30	25	28	27	21	65	2.65	−0.2	9	5,523	w.	32	sw.	20	5	13	13	6.3	10.2	7.0
Philadelphia	114	123	182	29.93	30.06	−.05	35.6	+3.0	61	15	43	12	2	28	31	31	25	69	1.91	−1.4	7	6,999	sw.	29	sw.	25	13	9	9	5.1	10.4	6.7
Reading	325	81	98	29.68	30.04		33.2		58	7	41	1	30	26	26	28	21	66	3.10	−0.4	7	5,318	w.	27	w.	25	11	13	7	4.9	14.9	7.5
Scranton	805	111	119	29.12	30.01	−.08	29.9	+3.3	54	13	37	6	2	23	21	26	23	80	1.40	−1.4	10	6,142	s.	20	w.	20	7	5	10	6.8	3.2	2.8
Atlantic City	52	37	172	29.99	30.05	−.06	35.6	+3.1	64	15	44	10	30	28	32	31	25	71	2.23	−1.3	9	13,171	w.	68	s.	24	15	11	5	3.7	11.1	8.5
Cape May	17	13	49				34.4	+0.3	63	15	43	10	30	28	30	31	27	75	2.10		8		nw.				13	11	7		6.5	5.3
Sandy Hook	22	10	55	29.99	30.01		33.4		54	13	40	13	2	27	30	29	22	66	1.37		10	13,285	w.	54	sw.	25	10	12	9	5.2	2.5	0.6
Trenton	190	159	183	29.82	30.03		33.6		58	7	42	7	30	25	32	28	22	68	1.74	−1.4	8	9,164	sw.	44	w.	25	9	13	9	5.2	11.0	4.2
Baltimore	123	100	215	29.94	30.07	−.05	36.3	+2.5	68	15	45	10	2	28	31	30	22	61	2.76	−0.7	5	8,018	sw.	47	sw.	25	19	4	8	4.4	14.3	6.0
Washington	112	62	85	29.95	30.07	−.06	35.9	+2.5	69	13	45	7	30	26	28	29	20	59	2.63	−0.8	8	5,152	nw.	36	nw.	25	16	5	10	4.6	10.0	5.0
Cape Henry	18	8	54	30.07	30.09		41.2		72	15	50	17	2	32	31	35	28	65	1.93	−1.2	6	9,017	sw.	38	nw.	28	16	3	12	4.6	0.3	0.0
Lynchburg	681	153	188	29.35	30.11	−.02	39.2	+1.7	73	14	49	6	2	29	34	33	25	61	2.53	−0.9	9	6,510	w.	35	w.	24	18	4	9	4.3	3.4	1.3
Norfolk	91	170	205	30.02	30.12	−.01	41.2	+0.6	74	15	50	12	2	32	35	35	27	62	1.51	−1.6	6	10,165	w.	50	w.	24	15	3	13	4.6	0.2	0.0
Richmond	144	11	52	29.95	30.12	−.01	38.9	+1.0	75	15	49	8	29	28	31	32	25	65	2.23	−1.0	7	6,250	w.	43	w.	24	13	8	10	4.3	4.6	2.4
Wytheville	2,304	49	55	27.68	30.15	+.01	33.8	+0.8	65	14	42	−4	2	26	27	28	23	71	1.95	−2.4	12	6,506	w.	38	sw.	19	14	7	10	4.8	4.6	1.5
South Atlantic States							45.6	0.0										67	0.87	−2.5										4.2		
Asheville	2,253	70	84	27.74	30.19	+.04	35.4	0.0	69	14	46	−5	2	25	35	30	24	70	1.15	−1.7	8	5,599	n.	26	nw.	21	17	7	7	4.2	0.6	0.0
Charlotte	779	56	62	29.30	30.16	+.01	41.8	+0.6	75	15	52	6	2	32	35	35	27	63	1.77	−2.2	6	3,971	sw.	34	sw.	24	18	4	9	3.9	T.	0.0
Hatteras	11	11	50	30.11	30.12	−.02	46.0	−1.1	68	16	53	20	2	39	31	41	37	74	0.80	−3.6	7	9,583	w.	46	sw.	24	14	7	10	4.8	T.	0.0
Raleigh	376	103	110	29.73	30.15	+.02	42.5	+1.4	75	15	52	8	2	33	32	36	30	69	0.86	−2.7	5	5,912	nw.	39	w.	24	17	5	9	4.5	T.	0.0
Wilmington	78	81	91	30.10	30.18	+.04	47.6	+1.1	77	15	58	14	2	38	33	40	33	66	1.07	−2.2	4	4,364	w.	37	sw.	24	17	7	7	3.8	T.	0.0
Charleston	48	11	92	30.15	30.20	+.05	48.8	−1.1	79	18	58	18	2	40	30	41	35	67	0.43	−2.6	3	6,379	sw.	30	sw.	24	12	12	7	4.6	0.0	0.0
Columbia, S. C.	351	41	57	29.80	30.20	+.05	46.6	+0.6	78	17	57	10	2	36	39	38	30	60	0.83	−2.5	6	4,680	w.	38	w.	24	16	9	6	3.8	0.2	0.0
Due West	711	10	55	29.42	30.22		42.8		75	18	54	6	2	32	41				2.30		6	6,634	sw.	42	w.	24	14	9	8	4.4	T.	0.0
Greenville, S. C.	1,039	139	146	29.04	30.16		42.4	+2.1	74	15	52	5	2	33	35	35	27	62	2.99		7	6,289	w.	38	w.	1	19	5	7	3.9	0.1	0.0
Augusta	182	62	77	30.00	30.20	+.04	47.0	0.0	80	18	58	10	2	36	41	40	34	70	0.75	−3.2	4	4,023	nw.	23	nw.	28	11	12	8	4.9	T.	0.0
Savannah	65	150	104	30.15	30.22	+.07	50.6	−0.8	78	15	61	17	2	41	30	42	35	65	0.39	−2.4	3	8,111	w.	39	w.	19	15	8	8	4.2	0.0	0.0
Jacksonville	43	209	245	30.18	30.23	+.08	52.5	−2.9	78	17	62	19	3	43	25	45	38	66	0.68	−2.1	5	7,449	sw.	32	sw.	24	13	7	11	4.8	0.0	0.0
Florida Peninsula							62.6	−2.9										76	0.40	−2.1										4.6		
Key West	22	10	64	30.14	30.16	+.06	66.6	−2.9	81	19	72	48	4	61	19	61	59	82	0.20	−1.8	4	7,238	ne.	30	nw.	27	15	7	9	4.2	0.0	0.0
Miami	25	71	164	30.16	30.19		64.0	−2.5	82	27	71	32	29	57	31	58	55	74	0.42	−2.3	8	7,207	e.	25	n.	21	9	15	7	5.3	0.0	0.0
Tampa	35	79	87	30.19	30.23	+.11	57.2	−3.2	81	16	67	26	3	48	29	49	44	72	0.59	−2.2	5	4,208	e.	20	nw.	28	15	9	7	4.5	0.0	0.0
Titusville	44	5		30.16	30.21		57.1		82	9	69	24	3	45	34				0.58		5		w.				12	10	9	4.6	0.0	0.0
East Gulf States							47.3	−0.9										67	1.44	−3.5										5.4		
Atlanta	1,173	190	216	28.94	30.22	+.07	42.6	0.0	72	17	51	1	2	34	31	36	28	60	2.83	−2.1	6	8,345	nw.	37	w.	24	10	11	10	5.3	0.2	0.0
Macon	370	78	87	29.82	30.23	+.07	45.5	−1.3	78	17	56	8	2	34	37	39	31	65	0.59	−4.6	4	4,302	nw.	23	nw.	19	10	11	10	5.2	T.	0.0
Thomasville	273	49	58	29.94	30.25	+.09	50.3	−0.7	79	17	60	18	2	41	31	42	36	66	0.94	−3.2	3	3,182	sw.	16	sw.	24	14	3	14	5.2	0.0	0.0
Apalachicola	36	42	49	30.21	30.25		50.3		69	17	57	22	3	43	24	45	41	77	0.61		5	5,121	n.	21	n.	28	14	5	12	4.6	0.0	0.0
Pensacola	56	149	185	30.20	30.26	+.12	50.0	−2.5	70	19	57	17	2	43	23	45	40	71	0.88	−3.1	6	8,562	n.	43	w.	24	9	6	16	5.8	0.0	0.0
Anniston	741	9	57	29.45	30.27	+.11	42.4	+0.2	75	16	53	4	2	31	38				2.48	−2.8	7	3,732	nw.	27	w.	24	12	13	6	4.7	0.1	0.0
Birmingham	700	11	48	29.47	30.26	+.10	44.4	−0.7	75	16	54	5	2	35	31	38	31	64	1.91	−3.4	7	4,667	s.	29	w.	24	11	13	7	4.9	0.2	0.0
Mobile	57	125	161	30.19	30.26	+.11	49.8	−1.7	74	24	58	18	2	42	26	44	38	69	0.91	−3.9	6	6,304	n.	20	nw.	19	9	5	17	5.9	0.0	0.0
Montgomery	223	100	112	30.01	30.27	+.11	46.8	−1.4	75	16	56	11	2	38	33	40	32	63	1.08	−4.1	5	4,604	sw.	30	w.	24	9	10	12	5.7	0.0	0.0
Corinth	469	6					42.2		76	16	52	3	3	33	34				2.82		7		s.				4	18	9		0.3	0.0
Meridian	375	87	95	29.84	30.26	+.10	46.8	−0.2	76	15	57	12	3	37	36	40	33	65	0.86	−4.7	4	4,163	sw.	32	w.	24	9	12	10	5.3	T.	0.0
Vicksburg	247	65	73	29.98	30.28	+.13	48.6	+0.4	76	17	57	13	3	40	27	42	37	70	1.07	−4.3	6	4,987	s.	30	w.	24	9	12	10	5.6	T.	0.0
New Orleans	53	76	84	30.20	30.26	+.13	52.5	−1.7	77	15	60	21	2	45	26	47	42	72	2.20	−2.0	8	4,249	ne.	20	nw.	19	10	5	16	6.0	0.0	0.0
West Gulf States							50.0	+1.7										68	0.97	−1.8										4.9		
Shreveport	249	77	93	29.98	30.26	+.12	49.1	+2.1	78	15	58	11	1	40	31	42	36	64	1.19	−2.7	5	4,271	s.	26	nw.	27	13	7	11	5.0	T.	0.0
Bentonville	1,303	11	44				39.7	+5.6	72	11	50	−5	1	29	31				1.34		7		s.		nw.		20	4	7		0.4	0.0
Fort Smith	457	79	94	29.70	30.20	+.05	42.9	+3.4	75	14	53	2	1	33	33	37	31	68	2.08	−0.5	5	5,069	e.	39	w.	24	16	6	9	4.3	0.0	0.0
Little Rock	357	136	144	29.83	30.22	+.07	43.8	+2.4	76	11	53	5	1	35	33	38	30	61	1.18	−3.6	7	6,221	s.	37	w.	24	15	8	8	4.2	T.	0.0
Austin	605	136	148	29.59	30.23		51.9	+2.4	79	10	62	15	2	42	41				0.36	−1.7	6	4,605	s.	28	s.	29	10	9	12	5.5	0.3	0.0
Brownsville	57	53	61		30.18		58.5	−1.3	82	13	67	29	1	50	34			79	1.33	−0.1	7	5,617	s.	26	n.	19	9	7	15		0.0	0.0
Corpus Christi	20	11	78	30.20	30.22	+.12	54.9	−1.1	76	10	62	22	2	48	30	50	46	80	2.22	0.0	5	7,569	n.	30	se.	20	11	6	14	5.8	0.0	0.0
Dallas	512	220	237	29.66	30.23		48.4		79	11	58	9	1	38	33				0.83		3	8,024	se.	44	sw.	18	18	5	8	3.8	0.0	0.0
Fort Worth	670	106	114	29.48	30.21	+.09	49.2	+3.8	80	11	60	10	1	38	39	41	35	64	0.46	−1.0	3	5,918	s.	28	nw.	24	15	7	9	4.5	0.0	0.0
Galveston	54	106	114	30.20	30.26	+.13	52.9	−0.9	69	15	58	20	2	48	19	49	45	82	0.41	−3.2	5	6,900	n.	27	n.	1	8	16	7	5.0	0.0	0.0
Groesbeck	461	11	56	29.74	30.23		49.6		78	15	59	14	2	40	36				0.34		4	6,903	s.	38	sw.	29	13	9	9	4.8	0.0	0.0
Houston	138	292	314	30.10	30.26		53.3	+0.6	78	16	62	16	2	45	27				0.40	−3.0	5	8,337	e.	33	nw.	19	9	12	10	5.3	T.	0.0
Palestine	510	64	72	29.69	30.24	+.12	49.8	+1.6	77	15	58	12	2	41	28	43	36	62	0.99	−2.9	5	5,079	s.	37	sw.	29	12	7	12	5.4	0.0	0.0
Port Arthur	34	58	66	30.21	30.25		52.4		73	14	60	18	2	45	23				0.17		5	5,362	s.	28	n.	19	11	5	15	5.7	0.0	0.0
San Antonio	693	119	132	29.48	30.22	+.12	53.0	+0.7	79	30	62	17	2	44	34	45	37	61	0.65	−1.0	6	4,474	ne.	30	nw.	19	11	10	10	5.1	T.	0.0
Taylor	583	55	63	29.64	30.26	+.15	51.0	+2.4	78	10	62	13	2	40	38				0.35	−2.5	4	5,104	s.	28	s.	29	11	12	8	4.7	0.5	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, January, 1928*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air												Precipitation			Wind										
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							34.0	+0.4										72	1.91	-1.9										5.7		
Chattanooga	762	189	213	29.39	30.23	+0.07	41.2	0.0	73	16	50	0	2	32	30	35	27	61	2.38	-2.9	8	5,474	sw.	40	sw.	24	8	16	7	5.1	0.2	0.0
Knoxville	995	102	111	29.12	30.20	+.05	38.4	-0.4	70	15	47	0	2	30	32	33	27	68	2.27	-2.4	8	4,832	sw.	36	sw.	19	10	14	7	5.1	T.	0.0
Memphis	399	76	97	29.79	30.23	+.07	41.8	+0.9	72	15	49	4	3	34	29	36	29	63	1.65	-3.2	9	5,936	sw.	45	w.	24	14	9	8	4.4	0.1	0.0
Nashville	546	168	191	29.63	30.24	+.08	39.4	+0.8	72	16	48	0	2	31	33	34	28	68	2.55	-2.2	8	6,109	w.	42	w.	24	10	13	8	4.8	0.1	0.0
Lexington	989	193	230	29.08	30.20	+.07	32.6	-0.3	67	16	40	-4	2	25	25				2.68	-1.2	9	10,006	sw.	52	w.	24	12	7	12	5.1	2.4	T.
Louisville	525	188	234	29.59	30.20	+.06	33.6	-0.8	70	16	42	-5	1	26	29	30	24	70	2.01	-2.0	7	8,281	s.	40	w.	24	10	10	11	5.3	2.5	0.5
Evansville	431	76	116	29.73	30.22	+.08	34.1	+0.6	71	16	42	-3	1	27	29	30	25	73	1.42	-2.3	9	7,530	sw.	42	w.	24	7	15	9	5.4	1.1	0.3
Indianapolis	822	194	230	29.22	30.14	+.02	28.9	+0.5	65	14	37	-8	1	21	28	26	21	75	1.74	-1.2	9	8,826	sw.	42	w.	20	10	6	15	5.7	1.2	0.4
Royal Center	736	11	55	29.27	30.12		25.2		62	14	32	-10	2	18	27				1.91		4	8,669	sw.	42	w.	20	7	7	17	6.4	0.3	0.2
Terre Haute	575	96	129	29.51	30.15		30.0		65	14	38	-6	1	22	26	27	23	79	1.83		7	7,196	sw.	37	w.	20	12	6	13	5.5	1.8	T.
Cincinnati	627	11	51	29.45	30.15	+.03	31.2	+0.9	68	14	39	-3	1	23	31	27	23	76	1.65	-1.8	7	6,883	sw.	33	w.	19	13	2	16	5.4	1.4	T.
Columbus	822	179	222	29.20	30.11	.00	29.6	+1.0	68	14	37	-1	1	22	28	26	22	78	1.44	-1.6	7	7,838	w.	50	w.	24	10	6	15	6.1	1.7	T.
Dayton	899	137	173	29.13	30.13		29.9	+0.4	64	14	37	-4	1	22	28	26	22	76	1.37	-1.6	8	8,007	sw.	44	w.	19	8	10	13	6.1	1.0	T.
Elkins	1,947	59	67	28.00	30.15	+.03	30.9	+0.5	63	14	40	-4	2	22	30	26	21	75	2.81	-0.5	13	5,578	w.	33	w.	25	5	7	19	7.0	7.8	1.8
Parkersburg	637	77	82	29.47	30.15	+.03	33.4	+0.9	68	14	42	2	2	25	31	28	24	73	1.46	-1.7	9	5,267	sw.	34	sw.	25	9	4	18	6.9	0.5	0.0
Pittsburgh	842	353	410	29.15	30.00	-.02	30.8	+0.1	62	14	38	2	1	24	29	26	20	69	1.30	-1.8	10	9,202	sw.	60	w.	19	4	13	14	7.1	1.2	0.1
Lower Lake Region							26.7	+2.2										80	1.95	-0.7										7.6		
Buffalo	767	247	280	29.09	29.95	-.12	26.2	+1.6	47	14	32	5	30	20	27	24	21	83	3.14	-0.2	20	17,139	sw.	62	w.	20	0	7	24	8.5	30.6	4.3
Canton	448	10	61	29.40	29.91		18.2	+1.9	43	13	27	-14	16	10	36				2.67	-0.5	21	8,600	w.	50	sw.	1	4	7	20	7.5	14.8	3.0
Oswego	335	76	91		29.94	-.13	27.2	+3.3	47	15	34	3	21	20	37			83	2.17	-0.8	22		sw.	39	w.	25	0	4	27		31.7	4.8
Rochester	523	86	102	29.37	29.96	-.11	27.6	+3.0	52	14	34	3	30	21	33	24	19	73	2.03	-0.9	18	8,559	sw.	37	w.	25	2	5	24	8.5	12.8	4.5
Syracuse	597	97	113	29.30	29.96	-.11	28.2	+5.2	51	15	35	6	21	22	39				1.25	-0.9	18	9,620	w.	45	w.	25	2	5	24	8.2	8.8	2.0
Erie	714	130	166	29.21	30.00	-.08	28.0	+1.2	50	14	34	2	30	22	30	25	21	76	1.85	-0.9	15	13,303	sw.	50	sw.	19	2	6	23	7.9	10.0	1.0
Cleveland	762	190	201	29.19	30.04	-.05	28.4	+1.9	60	14	35	0	3	22	32	25	21	78	2.03	-0.5	15	11,016	sw.	50	w.	20	3	6	22	7.8	9.8	0.7
Sandusky	629	5	67	29.36	30.06	-.03	28.5	+2.2	58	14	35	-1	3	22	27				1.53	-0.7	12	8,380	sw.	35	w.	20	4	11	16	7.1	3.6	1.0
Toledo	628	208	243	29.34	30.05	-.04	27.9	+2.1	57	14	35	0	3	21	31	25	21	77	1.48	-0.7	11	11,985	sw.	52	w.	20	6	9	16	6.9	3.9	0.5
Fort Wayne	856	113	124	29.11	30.07		26.8	-0.1	60	14	34	-5	1	19	29	24	21	82	1.51		7	8,191	sw.	39	w.	19	7	9	15	6.1	2.0	T.
Detroit	730	218	258	29.19	30.01	-.07	26.4	+2.0	54	14	32	2	3	20	26	24	21	84	1.36	-0.7	11	9,170	sw.	38	w.	20	4	8	19	7.5	5.5	2.0
Upper Lake Region							21.0	+2.5										83	1.35	-0.5										7.0		
Alpena	609	13	92	29.23	29.92	-.12	21.9	+2.8	47	10	20	-2	30	15	28	20	18	83	1.54	-0.4	14	8,139	w.	38	nw.	20	4	12	15	7.0	10.8	3.2
Escanaba	612	54	60	29.25	29.94	-.11	19.0	+3.6	45	10	20	-5	3	12	35	17	14	82	1.09	-0.4	7	6,500	nw.	32	n.	14	9	6	16	6.2	7.9	8.0
Grand Haven	632	54	89	29.29	30.00	-.07	26.0	+1.7	46	14	31	1	30	21	22	25	23	86	1.58	-0.8	15	10,677	w.	53	nw.	19	3	3	25	8.5	8.8	2.1
Grand Rapids	707	70	87	29.21	30.01	-.06	26.0	+1.5	53	14	31	1	30	21	25	24	21	81	1.32	-1.0	14	5,138	w.	32	w.	19	1	9	21	8.1	10.4	3.0
Houghton	668	64	99	29.16	29.92	-.13	17.4	+2.7	41	6	23	-4	3	12	27				3.00	+1.0	19	7,028	w.	36	nw.	20	2	4	25	8.5	29.4	17.6
Lansing	878	11	62	29.02	30.00		24.1	+1.7	51	14	30	-5	30	18	25	23	22	92	1.50	-0.3	13	5,279	sw.	22	nw.	20	3	10	17	7.4	5.6	1.9
Ludington	637	60	66	29.25	29.97		24.4		41	14	29	-4	30	20	22	24	21	85	1.48		15	9,423	w.	40	w.	19	5	3	23	7.8	16.0	6.3
Marquette	734	77	111	29.10	29.93	-.11	19.9	+3.6	46	6	27	-4	3	13	29	17	14	83	1.83	-0.5	15	7,083	w.	34	nw.	19	4	9	18	7.4	17.6	17.4
Port Huron	638	70	120	29.26	29.97	-.09	24.8	+2.5	49	14	31	-2	30	19	25	22	19	82	1.15	-0.7	8	9,088	sw.	44	w.	19	4	11	17	6.8	7.1	3.2
Sault Sainte Marie	614	11	52	29.19	29.92	-.11	15.8	+2.5	39	6	23	-10	28	9	30	15	12	84	2.35	+0.2	19	5,685	w.	33	nw.	19	3	4	24	8.3	21.0	16.6
Chicago	673	7	131	29.32	30.08	-.02	25.2	+1.5	60	14	32	-6	2	19	27	23	18	73	0.73	-1.2	7	8,840	sw.	41	nw.	19	11	8	12	5.9	0.6	T.
Green Bay	617	109	141	29.30	29.99	-.07	18.8	+3.1	48	12	26	-9	28	12	32	17	14	82	0.36	-1.3	7	8,504	w.	38	w.	19	10	7	14	6.0	3.9	1.7
Milwaukee	681	125	221	29.26	30.03	-.05	23.3	+2.7	52	14	30	-6	28	17	27	21	17	76	0.36	-1.4	5	10,835	w.	39	nw.	19	11	8	12	5.4	2.0	T.
Duluth	1,133	5	47	28.72	30.00	-.09	10.8	+2.9	42	10	19	-27	2	2	35	10	8	93	0.70	-0.3	8	10,307	w.	61	nw.	19	12	11	8	4.8	7.0	9.5
North Dakota							13.4	+8.8										82	0.15	-0.4										4.9		
Moorhead	940	50	58	29.02	30.09	-.05	12.6	+8.8	43	10	22	-25	2	4	41	11	9	87	0.22	-0.4	6	5,813	sw.	36	nw.	19	10	6	15	5.7	1.6	6.9
Bismarck	1,674	8	57	28.26	30.14	+.01	15.2	+7.4	45	12	25	-34	2	6	38	13	9	79	0.23	-0.2	3	5,556	nw.	38	nw.	19	13	11	7	4.4	4.2	4.0
Devils Lake	1,478	11	44	28.41	30.08	-.04	11.0	+10.7	41	10	20	-25	1	2	30	9	7	87	0.10	-0.5	6	6,942	w.	38	nw.	19	12	12	7	4.4	1.6	1.0
Ellendale	1,457	10	56	28.48	30.11		16.0		48	10	25	-26	2	7	35				0.26		6	9,637	nw.	52	nw.	19	9	10	12	5.5	2.2	1.0
Grand Forks	833	12	67				11.8		44	10	21	-22	2	2	41				0.29		5		nw.	46	nw.	19	13	9	9		3.6	3.8
Williston	1,878	41	48	28.07	30.15	+.04	14.6	+8.2	46	9	24	-32	1	6	41	13	9	77	0.05	-0.5	2	4,953	sw.	33	nw.	19	13	10	8	4.4	0.8	2.1
Upper Mississippi Valley							25.9	+4.4										78	0.50	-1.0										5.3		
Minneapolis	918	102	208	29.04	30.07		17.2	+4.5	46	10	25	-20	2	10	37				0.33	-0.5	7	7,992	w.	43	nw.	19	9	9	13	6.0	3.2	3.7
St. Paul	837	236	261	29.12	30.07	-.04	16.6	+4.0	45	10	24	-20	2	9	37				0.31	-0.6	6	8,452	sw.	50	w.	19	9	10	12	5.9	3.0	10.1
La Crosse	714	11	48	29.26	30.07	-.04	20.5	+4.4	50	10	29	-15	2	12	36	18	15	82	0.50	-0.6	9	3,162	nw.	20	nw.	19	7	12	12	5.9	3.4	0.5
Madison	974	70	78	28.96	30.07	-.03	21.0	+4.3	50	10	28	-11	2	14	36	19	17	86	0.40	-1.0	8	6,656	nw.	32	w.	19	10	8	13	5.5	1.7	1.3
Wausau	1,247	4		28.61	30.01		15.0		44	12	23	-20	2	7	35				0.52		7		w.				10	9	12	5.8	6.6	6.9
Charles City	1,015	10	49	28.98	30.10	-.04	21.0	+7.3	48	10	29	-17	2	13	33	19	16	86	0.27	-0.7	7	5,061	w.	29	nw.	19	10	14	7	4.6	1.3	1.0
Davenport	606	71	79	29.43	30.12	.00	26.1	+4.3	61	14	34	-9	2	18	31	24	20	81	0.34	-1.1	7	5,188	w.	30	nw.	19	11	8	12	5.4	2.5	0.6
Des Moines	861	84	97	29.18	30.13	-.01	28.0	+7.9	65	10	37	-8	1	19	32	24	10	71	0.11	-1.0	3	5,072	nw.	22	nw.	19	14	7	10	5.1	T.	0.0
Dubuque	700	81	96	29.30	30.09	-.03	23.8	+4.7	54	10	32	-10	2	16	33	22	18	81	0.20	-1.1	5	4,664	nw.	32	nw.	20	11	9	11	5.3	0.7	0.4
Keokuk	614	64	78	29.45	30.16	+.02	29.5	+4.6	64	14	37	-10	2	22	27	25	20	69	0.41	-1.2	2	5,931	sw.	36	nw.	19	12	10	9	4.9	0.8	T.
Cairo	358	87	93	29.82	30.21	+.05	36.6	+1.7	70	16	44	-2	1	29	31	32	26	70	1.65	-2.1	8	6,522	s.	30	sw.	24	11	10	10	5.4	T.	0.0
Peoria	609	11	45	29.45	30.14	+.02	26.5	+3.4	64	14	34	-14	2	18	26	24	21	85	0.36	-1.4	5	5,401	s.	28	nw.	19	16	7	8	4.2	1.0	0.4
Springfield, Ill.	636	10	91	29.44	30.15	+.02	29.6	+3.1	67	14	37	-9	2	22	29	27	23	81	1.02	-1.0	5	6,344	w.	28	w.	19	13	5	13	5.3	1.9	0.4
Hannibal	534	74	109	29.56	30.16	+.03	30.9	+3.8	70	14	39	-14	2	22	29				0.41	-1.8	5	6,743	sw.	29	w.	19	15	7	9	4.6	0.6	T.
St. Louis	568	265	303	29.54	30.17	+.03	34.7	+3.9	71	14	42	-5	1	27	28	30	24	70	1.01	-0.4	4	9,234	sw.	37	w.	19	15	7	9	4.5	1.1	T.
Missouri Valley							29.2	+6.3										73	0.22	-0.8										4.3		
Columbia, Mo.	784	11	84	29.30	30.17	+.04	32.8	+3.6	71	14	41	-9	1	24	27				0.94	-1.3	4	5,795	sw.	28	nw.	24	15	8	8	4.5	1.9	0.0
Kansas City	963	161	181	29.11	30.18	+.03	33.6	+5.4	64	14	41	-8	1	26	27	30	24	69	0.21	-1.0	3	7,709	sw.	36	w.	18	16	8	7	4.0	1.0	T.
St. Joseph	967	11	49	29.09	30.16		31.9		64	10	40	-8	1	23	29	27	21	69	0.02		2	5,693	sw.	33	nw.	19	15	10	6	3.8	0.1	T.
Springfield, Mo.	1,324	98	104	28.72	30.16	+.02	37.0	+3.5	72	14	46	-8	1	28	26	32	25	68	0.72	-1.9	6	6,963	s.	30	nw.	24	16	8	7	4.0	0.9	0.0
Iola	984	11	50	29.10	30.20	+.06	34.2	+4.4	69	14	44	-12	3	24	35				0.20	-1.2	4	4,430	s.	22	ne.	24	19	5	7	4.0	0.5	0.0
Topeka	987	92	107				33.4	+5.8	68	10	43	-8	1	24	32				0.02	-0.9	2	6,152	sw.	30	nw.	24	18	8	5	3.2	0.2	0.0
Lincoln	1,189	11	81	28.85	30.16	+.01	30.4	+7.6	68	10	41	-11	1	20	43	25	17	64	0.06	-0.6	2	6,349	s.	40	nw.	19	14	7	10	4.7	0.3	0.0
Omaha	1,105	115	122	28.93	30.16	+.01	29.6	+7.7	67	10	38	-11	1	21	31	26	20	70	0.01	-0.7	1	5,496	nw.	31	nw.	19	13	11	7	4.3	T.	0.0
Valentine	2,598	47	54	27.36	30.18	+.06	27.0	+8.1	63	10	38	-22	1	16	42	22	18	76	0.26	-0.3	6	5,580	w.	38	nw.	19	12	12	7	4.5	3.4	T.
Sioux City	1,135	94	164	28.90	30.16	+.01	25.8	+8.0	62	10	34	-13	1	17	32	23	19	77	0.04	-0.5	3	7,814	nw.	45	nw.	19	13	11	7	4.7	0.3	T.
Huron	1,306	69	74	28.70	30.17	+.01	19.0	+7.7	51	12	29	-24	2	9	35	17	13	80	0.02	-0.5	1	5,515	nw.	33	nw.	19	13	10	8	4.5	0.3	T.
Pierre	1,572	70	75		30.20	+.07	22.8	+6.8	55	10	32	-22	1	14	40			84	0.14	-0.3	3	5,034	nw.	26	nw.	19	16	4	11		1.4	T.
Yankton	1,233	49	57	28.78	30.16	.00	24.5	+7.2	58	10	34	-15	1	15	38				0.02	-0.6	2	5,150	nw.	31	nw.	19	10	13	8	5.2	T.	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, January, 1928*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							**25.4**	**+5.4**										**73**	**0.54**	**−0.4**										**6.3**		
Billings	3,140	5	----	------	------	------	23.6	------	55	12	33	−24	1	14	50	----	----	----	1.63	------	9	------	nw.	----	------	----	13	8	10	----	25.0	----
Havre	2,505	11	44	27.43	30.18	+0.08	20.8	+7.9	50	9	30	−28	1	12	40	10	15	78	0.14	−0.6	5	5,976	sw.	31	sw.	8	11	5	15	6.0	2.3	T.
Helena	4,110	87	112	25.90	30.26	+.11	24.0	+3.8	55	10	32	−20	1	16	27	21	17	77	1.41	+0.5	10	4,433	sw.	52	sw.	11	4	6	21	7.5	19.0	3.8
Kalispell	2,973	48	56	27.09	30.27	+.15	23.3	+2.9	49	12	29	−9	1	18	19	22	20	88	1.15	−0.4	11	2,299	nw.	25	w.	12	1	5	25	8.5	10.9	9.0
Miles City	2,371	48	55																													
Rapid City	3,259	50	58	26.66	30.22	+.12	27.4	+5.4	69	10	38	−19	1	17	33	22	16	64	0.18	−0.3	4	4,595	nw.	30	nw.	18	5	13	13	6.1	1.9	0.0
Cheyenne	6,088	84	101	24.01	30.15	+.10	31.8	+6.3	57	10	42	−13	1	22	48	24	16	56	0.33	−0.1	8	11,026	w.	50	w.	12	10	8	13	5.5	4.0	T.
Lander	5,372	60	68	24.60	30.26	+.14	23.2	+4.9	58	12	35	−15	1	11	41	18	12	66	0.31	−0.1	5	2,638	sw.	36	w.	13	10	18	3	4.8	3.1	T.
Sheridan	3,790	10	47	26.15	30.21	------	23.8	------	58	12	35	−28	1	12	39	21	17	79	1.36	------	11	2,305	nw.	32	nw.	18	4	16	11	6.7	15.5	6.0
Yellowstone Park	6,241	11	48	23.95	30.30	+.16	22.2	+4.6	42	9	30	−6	20	15	26	20	16	75	0.70	−1.5	12	5,453	s.	28	s.	13	5	4	22	7.3	7.9	8.4
North Platte	2,821	11	51	27.15	30.19	+.07	30.3	+7.4	67	13	43	−13	1	17	42	24	20	76	0.13	−0.3	2	4,207	w.	26	nw.	19	16	9	6	3.9	1.3	0.0
Middle Slope							**36.4**	**+6.0**										**59**	**0.17**	**−0.5**										**3.5**		
Denver	5,292	106	113	24.76	30.15	+.10	36.6	+6.8	70	10	48	−10	1	25	38	28	16	48	0.24	−0.2	3	5,177	s.	28	ne.	2	19	10	2	3.5	3.9	0.0
Pueblo	4,685	80	86	25.35	30.16	+.11	34.8	+4.9	71	12	51	−14	1	18	53	27	16	53	0.01	−0.3	1	4,338	nw.	31	w.	22	18	10	3	3.2	0.0	0.0
Concordia	1,392	50	58	28.67	30.20	+.06	32.9	+6.5	67	10	44	−10	1	22	44	27	19	63	0.11	−0.6	3	4,910	nw.	28	nw.	24	17	7	7	3.9	1.0	T.
Dodge City	2,509	11	51	27.52	30.21	+.10	36.6	+7.6	76	14	51	−6	1	22	44	27	18	58	0.03	−0.4	2	5,426	nw.	24	nw.	19	26	2	3	2.1	0.3	0.0
Wichita	1,358	139	158	28.70	30.18	+.05	36.3	+5.0	68	14	46	−4	1	26	32	31	24	66	0.10	−0.7	3	7,663	s.	32	s.	23	19	7	5	3.3	0.5	0.0
Broken Arrow	765	11	56	29.36	30.21	------	39.9	------	73	14	50	1	1	29	34	----	----	----	1.30	------	3	8,372	s.	46	nw.	24	17	5	9	4.7	0.0	0.0
Oklahoma City	1,214	10	47	28.88	30.21	+.10	41.5	+5.1	75	14	52	2	1	31	34	33	26	64	0.51	−0.8	2	6,484	s.	30	nw.	24	19	4	8	3.9	T.	0.0
Southern Slope							**45.0**	**+2.2**										**52**	**0.42**	**−0.3**										**3.7**		
Abilene	1,738	10	52	28.36	30.21	+.12	46.0	+1.8	82	14	58	9	1	34	40	36	26	53	0.95	0.0	2	5,722	s.	25	s.	23	10	12	9	4.8	0.0	0.0
Amarillo	3,676	10	49	26.38	30.19	+.13	41.4	+6.1	78	14	55	−1	1	28	42	31	20	51	T.	−0.6	0	5,631	sw.	30	sw.	18	24	4	3	2.5	0.0	0.0
Del Rio	944	64	71	29.19	30.20	+.14	49.8	−2.5	80	30	60	20	1	40	42	43	36	68	0.71	−0.1	6	4,644	se.	28	nw.	26	15	5	11	4.9	0.9	0.0
Roswell	3,566	75	85	26.48	30.16	+.12	42.8	+3.6	76	14	60	9	1	26	54	31	14	37	0.00	−0.4	0	5,063	s.	34	nw.	18	22	6	3	2.7	0.0	0.0
Southern Plateau							**43.3**	**+2.6**										**47**	**T.**	**−0.7**										**2.5**		
El Paso	3,778	152	175	26.32	30.18	+.17	46.4	+1.4	70	14	59	18	1	34	35	35	20	39	T.	−0.5	0	5,082	nw.	39	w.	23	24	3	4	2.3	T.	0.0
Santa Fe	7,013	38	53	23.31	30.20	+.16	33.8	+5.0	56	14	40	9	1	22	34	25	14	47	0.01	−0.7	1	4,386	ne.	25	n.	18	24	5	2	2.5	T.	0.0
Flagstaff	6,907	10	59	23.44	30.21	+.16	28.0	+1.3	58	13	45	−7	19	11	46	22	----	62	1.11	------	3	------	n.	----	sw.	----	23	5	3	----	16.0	T.
Phoenix	1,108	10	82	28.96	30.13	+.10	53.2	+2.0	78	28	60	28	19	37	39	42	28	45	T.	−1.2	0	2,604	e.	15	ne.	27	16	11	4	3.3	0.0	0.0
Yuma	141	9	54	30.00	30.15	+.10	56.6	+2.2	80	12	70	33	17	44	32	45	31	41	T.	−0.4	0	3,877	n.	23	n.	27	24	5	2	2.0	0.0	0.0
Independence	3,957	5	25	26.12	30.22	+.15	42.0	+3.8	72	29	57	15	18	27	39	31	----	----	0.01	------	1	------	nw.	----	------	----	22	4	5	----	T.	0.0
Middle Plateau							**30.5**	**+2.3**										**72**	**0.37**	**−0.7**										**4.3**		
Reno	4,532	74	81	25.63	30.30	+.17	34.6	+2.1	57	12	46	7	16	23	39	30	25	70	0.14	−1.6	5	2,957	w.	34	sw.	13	13	12	6	4.5	0.5	0.0
Tonopah	6,090	12	20	------	------	------	33.6	------	56	9	41	8	16	26	23	28	21	59	0.12	------	1	------	w.	----	------	----	----	----	----	----	----	----
Winnemucca	4,344	18	56	25.83	30.35	+.19	29.2	+0.6	52	13	40	1	18	18	34	26	21	73	0.45	−0.6	5	4,036	sw.	22	w.	13	10	20	1	4.0	5.5	0.0
Modena	5,473	10	43	24.75	30.26	+.16	27.7	+1.0	54	13	39	−2	18	16	35	24	20	78	0.18	−0.6	4	4,917	w.	33	sw.	14	17	11	3	3.6	2.4	0.0
Salt Lake City	4,360	163	203	25.82	30.33	+.18	30.2	+1.0	56	13	36	11	22	24	33	27	24	81	0.81	−0.5	6	3,021	nw.	26	n.	14	8	7	16	6.4	10.8	0.2
Grand Junction	4,062	60	68	25.56	30.25	+.19	30.6	+6.6	59	14	42	4	1	19	38	25	20	69	0.27	−0.2	3	2,646	se.	29	w.	23	19	11	1	3.2	0.9	0.0
Northern Plateau							**29.3**	**+0.6**										**85**	**1.76**	**+0.2**										**8.4**		
Baker	3,471	48	53	26.65	30.36	+.20	25.6	+0.7	46	13	33	3	18	18	23	24	22	85	1.02	−0.3	15	3,483	se.	16	se.	13	3	5	23	8.1	11.0	1.5
Boise	2,739	78	86	27.42	30.39	+.20	29.4	−0.4	44	29	35	15	18	24	19	27	25	83	1.96	+0.2	11	2,030	nw.	14	se.	29	6	7	18	7.3	8.1	0.0
Lewiston	757	40	48	29.45	30.29	+.13	33.6	+1.1	50	11	38	10	1	29	17	----	----	----	2.46	+0.9	12	2,272	e.	15	ne.	8	1	3	27	8.9	12.6	0.0
Pocatello	4,477	60	68	25.64	30.32	+.12	28.9	+4.2	50	13	35	5	22	22	32	26	22	77	0.46	−0.2	8	5,842	se.	30	sw.	14	3	6	22	8.0	5.8	0.0
Spokane	1,929	101	110	28.18	30.31	+.19	28.6	+1.1	45	12	33	6	1	24	17	28	27	90	1.75	−0.3	11	2,709	ne.	21	s.	11	0	2	29	9.4	9.3	4.7
Walla Walla	991	57	65	29.20	30.32	+.17	29.7	−3.0	56	12	34	6	1	26	22	28	27	89	2.88	+0.9	14	1,905	s.	14	sw.	12	2	1	28	8.9	14.5	0.6
North Pacific Coast Region							**42.4**	**+2.1**										**86**	**6.26**	**−0.7**										**8.5**		
North Head	211	11	56	29.87	30.10	+.05	45.2	+3.1	59	27	49	31	1	41	16	43	41	86	7.43	−0.6	22	12,278	se.	50	s.	7	4	1	26	8.5	0.0	0.0
Port Angeles	29	8	53	------	30.16	------	41.3	------	56	8	46	23	1	37	15	----	----	----	3.41	−2.0	16	3,341	sw.	18	w.	13	3	4	24	----	3.0	0.0
Seattle	125	215	250	30.03	30.16	+.11	42.3	+2.8	58	8	47	22	1	38	15	41	38	86	4.97	+0.2	18	4,498	se.	30	s.	11	0	2	29	9.2	2.3	0.0
Tacoma	194	172	201	29.96	30.18	+.14	41.4	+2.6	56	9	46	19	15	36	19	----	----	----	6.03	−0.1	23	3,566	s.	28	s.	11	0	8	23	8.8	4.0	0.0
Tatoosh Island	86	9	53	30.00	30.10	+.12	44.1	+2.9	56	9	47	28	1	42	12	42	41	80	13.96	+1.8	21	14,105	e.	66	e.	1	4	4	23	8.2	1.3	0.0
Yakima	1,071	5	----	------	------	------	29.0	------	54	12	34	8	1	24	28	28	----	86	1.41	------	10	------	nw.	----	------	----	2	3	26	8.8	13.1	1.0
Medford	1,425	4	80	28.69	30.24	------	39.8	------	64	29	48	19	17	32	26	37	35	87	2.08	------	11	------	nw.	26	se.	28	3	7	21	8.1	0.6	0.0
Portland, Oreg.	153	68	106	30.05	30.22	+.14	38.6	−0.8	59	11	43	15	1	34	18	36	34	83	5.11	−1.5	18	3,510	e.	23	sw.	12	1	7	23	8.0	2.2	0.0
Roseburg	510	75	99	29.64	30.21	+.11	43.1	+1.9	62	1	50	26	18	36	30	42	40	87	2.90	−2.4	17	1,537	s.	15	s.	20	3	6	22	8.1	0.0	0.0
Middle Pacific Coast Region							**48.1**	**+0.7**										**80**	**2.10**	**−2.6**										**6.1**		
Eureka	62	73	89	30.15	30.22	+.12	50.0	+2.1	67	1	56	30	16	44	24	47	44	82	3.58	−4.0	13	4,157	se.	27	w.	13	5	6	20	7.0	0.0	0.0
Red Bluff	332	50	56	29.90	30.27	+.15	44.8	−1.0	67	27	52	23	18	38	28	42	38	79	2.37	−2.4	10	2,747	nw.	24	nw.	15	9	7	15	6.2	0.0	0.0
Sacramento	69	106	117	30.18	30.25	+.13	46.6	+0.8	64	29	52	29	16	41	23	44	41	82	1.17	−2.6	8	3,967	se.	20	nw.	14	8	9	14	6.1	0.0	0.0
San Francisco	155	208	243	30.06	30.23	+.12	50.4	+0.5	63	27	55	40	18	46	16	47	43	78	2.40	−2.1	9	4,098	n.	30	nw.	13	11	10	10	5.3	0.0	0.0
San Jose	141	12	110	30.09	30.24	------	48.6	+0.3	72	28	58	26	18	39	30	----	----	----	0.98	−2.0	7	2,745	nw.	19	w.	13	8	12	11	5.5	0.0	0.0
South Pacific Coast Region							**55.3**	**+3.6**										**63**	**0.10**	**−2.1**										**4.0**	—	
Fresno	327	89	98	29.90	30.27	+.17	46.6	+0.4	72	29	54	29	16	39	28	43	39	76	0.08	−1.5	3	2,316	e.	22	nw.	22	13	6	12	5.4	T.	0.0
Los Angeles	338	159	191	29.79	30.16	+.08	61.4	+6.8	84	12	72	40	16	51	26	49	37	46	0.02	−3.1	1	3,450	ne.	15	sw.	15	21	9	1	2.7	0.0	0.0
San Diego	87	62	70	30.04	30.13	+.06	57.8	+3.5	81	27	67	40	18	49	28	50	44	66	0.21	−1.8	2	3,177	nw.	24	s.	15	16	10	5	3.9	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.95	30.04	------	74.4	−0.6	80	21	79	66	11	70	13	----	----	----	3.87	−0.8	27	10,332	e.	34	e.	30	3	25	3	5.7	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.78	29.85	+.02	80.0	+0.1	90	21	88	69	3	72	18	73	72		0.02	−0.8	1	------	nw.	----	n.	----	10	21	0	4.6	0.0	0.0
Colon	38	7	97	29.86	29.89	+.02	81.6	+0.1	88	19	87	73	29	76	13	74	72		1.71	−1.9	19	------	n.	----	n.	----	1	27	3	5.8	0.0	0.0
Alaska																																
Juneau	80	11	54	[1] 29.75	[1] 29.84	------	33.0	------	46	7	37	19	23	29	18	32	29	84	13.46	------	21	5,179	se.	32	se.	7	5	3	23	8.0	14.6	2.2
Hawaiian Islands																																
Honolulu	38	86	100	[1] 30.05	[illegible]	------	71.8	------	80	10	76	64	1	68	13	64	61	69	1.97	−1.8	13	7,803	e.	31	e.	14	8	14	9	5.3	0.0	0.0

[1] Pressure not corrected to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, January, 1928*

Station	Altitude above mean sea level Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	Inches	Inches	Inches	°F.	°F.	°F.	°F.	°F.	°F.	Inches	Inches	Inches
Cape Race, N. F.	99				26.2		31.9	20.6	45	3	5.31		21.4
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20	29.77	29.80	−0.18	9.3	+1.3	17.0	1.6	34	−10	3.05	+0.20	30.5
Quebec, Que.	296	29.52	29.86	−.16	10.4	+1.3	17.5	3.3	34	−14	6.35	+2.34	61.8
Doucet, Que.	1,236												
Montreal, Que.	187	29.66	29.88	−.16	15.9	+4.2	23.8	8.1	39	−10	3.89	+0.16	37.3
Ottawa, Ont.	236	29.63	29.91	−.12	15.2	+5.6	24.1	6.3	39	−16	3.70	+0.71	35.3
Kingston, Ont.	285	29.60	29.94	−.11	21.4	+4.3	27.9	14.9	40	−6	2.62	−0.83	15.0
Toronto, Ont.	379	29.51	29.94	−.11	25.2	+3.8	30.9	19.5	44	1	2.30	−0.62	9.3
Cochrane, Ont.	930				0.1		9.9	−9.6	32	−34	1.57		15.7
White River, Ont.	1,244	28.46	29.84	−.17	2.7	+3.1	16.2	−10.7	34	−46	1.23	−0.46	12.3
London, Ont.	808				23.1		29.1	17.2	44	−18	4.58		38.0
Southampton, Ont.	656	29.17	29.91	−.12	22.3	+1.9	28.2	16.4	40	−5	4.13	+0.08	29.6
Parry Sound, Ont.	688	29.16	29.89	−.12	17.2	+3.4	24.3	10.2	38	−16	3.57	−0.51	33.5
Port Arthur, Ont.	644	29.20	29.94	−.13	12.0	+8.9	20.5	3.4	41	−21	0.55	−0.27	5.5
Winnipeg, Man.	760	29.15	30.02	−.09	8.5	+15.3	15.7	1.3	41	−25	0.39	−0.49	3.7
Minnedosa, Man.	1,690	28.12	30.04	−.06	7.5	+14.7	16.3	−1.3	40	−30	0.24	−0.56	2.4
Le Pas, Man.	860				3.0		12.4	−6.4	43	−39	0.23		1.3
Qu'Appelle, Sask.	2,115	27.68	30.04	−.04	10.0	+13.8	19.0	1.0	44	−36	0.24	−0.26	2.4
Moose Jaw, Sask.	1,759				14.6		24.2	5.0	46	−35	0.16		1.5
Swift Current, Sask.	2,392	27.43	30.07	−.02	16.3	+13.2	25.7	7.0	46	−34	0.33	−0.31	3.3
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.40	30.06	−.03	7.4	+15.8	17.9	−3.0	49	−41	0.12	−0.85	1.2
Battleford, Sask.	1,592	28.25	30.08	.00	10.8	+16.7	21.7	0.0	52	−41	0.10	−0.30	1.0
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.90	30.16	+.10	41.8	+3.3	44.7	38.9	52	24	6.12	+0.73	7.6
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	30.05	30.22	+.09	63.7	+1.7	70.4	57.1	75	51	3.94	−1.00	0.0

LATE REPORTS FOR NOVEMBER AND DECEMBER, 1927

NOVEMBER, 1927

Winnipeg, Man.	760	29.23	30.10	+0.06	17.3	−0.7	23.0	11.5	48	−10	0.95	−0.13	6.5

DECEMBER, 1927

Sydney, C. B. I.	48	29.81	29.86	−0.03	31.7	+3.5	37.5	25.9	58	15	5.34	+0.71	22.0
Halifax, N. S.	88	29.64	29.75	−.21	31.0	+3.4	37.8	24.3	58	10	6.49	+1.37	6.4
Yarmouth, N. S.	65	29.81	29.88	−.10	33.7	+3.0	39.2	28.3	56	16	5.28	+0.51	14.5
Charlottetown, P. E. I.	38	29.70	29.83	−.11	29.1	+4.8	34.9	23.4	59	11	4.45	+0.70	31.2
Chatham, N. B.	28	29.81	29.84	−.10	22.0	+5.0	30.0	14.0	51	−8	4.92	+1.70	37.6
Father Point, Que.	20	29.92	29.95	.00	22.0	+6.6	28.7	15.3	46	2	4.72	+1.89	38.4
Winnipeg, Man.	760	29.30	30.20	+.18	−2.8	−6.9	3.9	−9.5	23	−28	0.66	−0.25	6.6
Medicine Hat, Alb.	2,144	27.74	30.14	+.17	0.7	−17.5	10.4	−9.1	44	−35	0.57	+0.02	5.7
Calgary, Alb.	3,428	26.38	30.19	+.25	3.2	−15.0	12.5	−6.1	49	−32	1.20	+0.70	12.9
Banff, Alb.	4,521	25.30	30.18	+.24	2.4	−16.7	10.8	−6.0	40	−45	1.15	+0.06	11.5
Edmonton, Alb.	2,150	27.70	30.15	+.22	−2.8	−15.9	4.8	−10.4	38	−40	0.97	+0.27	7.7
Kamloops, B. C.	1,262	28.89	30.26	+.32	13.9	−15.0	18.6	9.3	40	−25	3.50	+2.72	33.2
Barkerville, B. C.	4,180	25.56	30.04	+.16	8.7	−12.2	14.3	3.1	35	−27	5.20	+2.03	52.0
Estevan Point, B. C.	20				38.2		43.6	32.9	54	22	9.63		1.2
Prince Rupert, B. C.	170				32.0		36.5	27.5	50	15	9.25		14.3

Chart I. Departure (°F.) of the Mean Temperature from the Normal, January, 1928

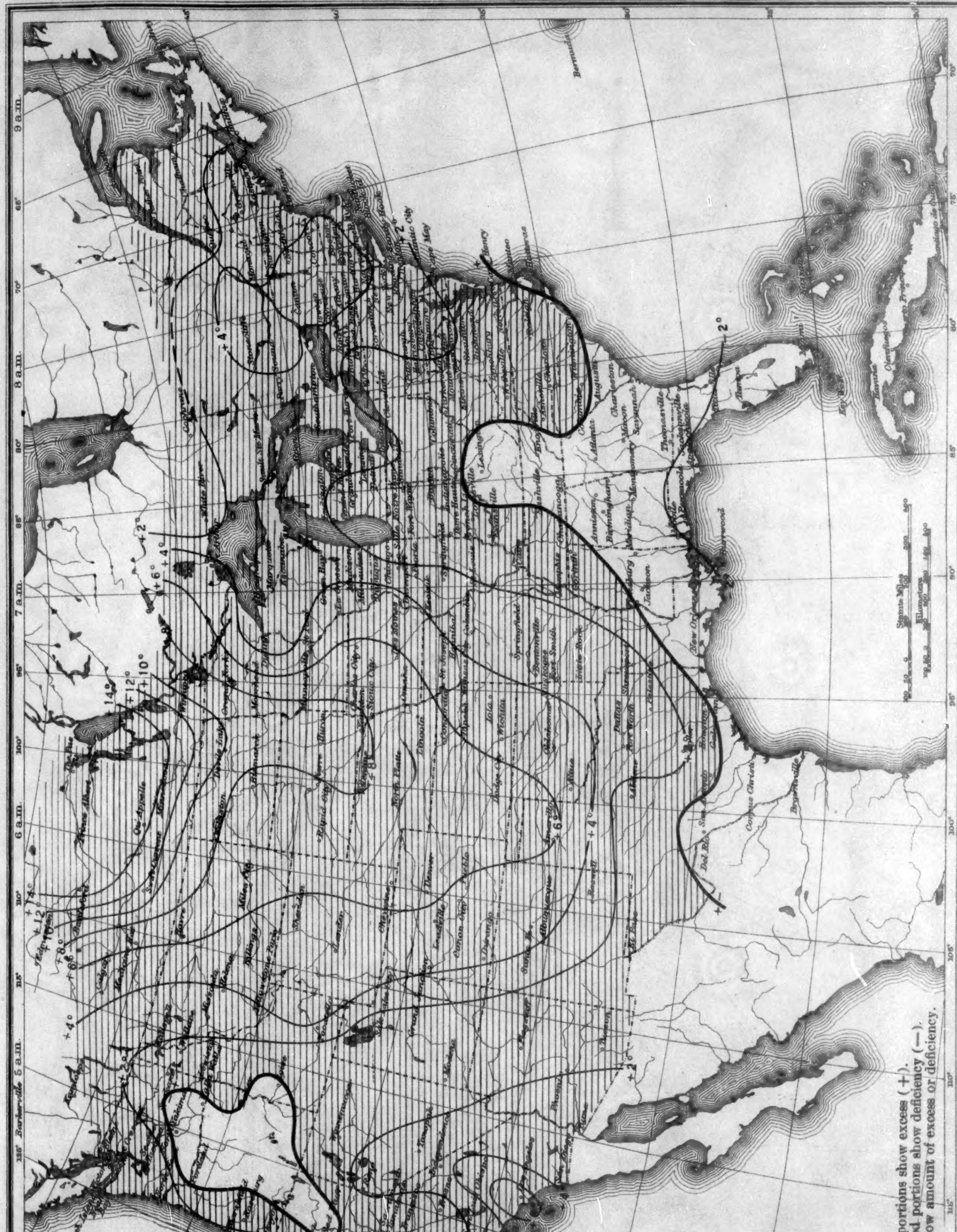

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Chart II. Tracks of Centers of Anticyclones, January, 1928. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by Wilfred P. Day)

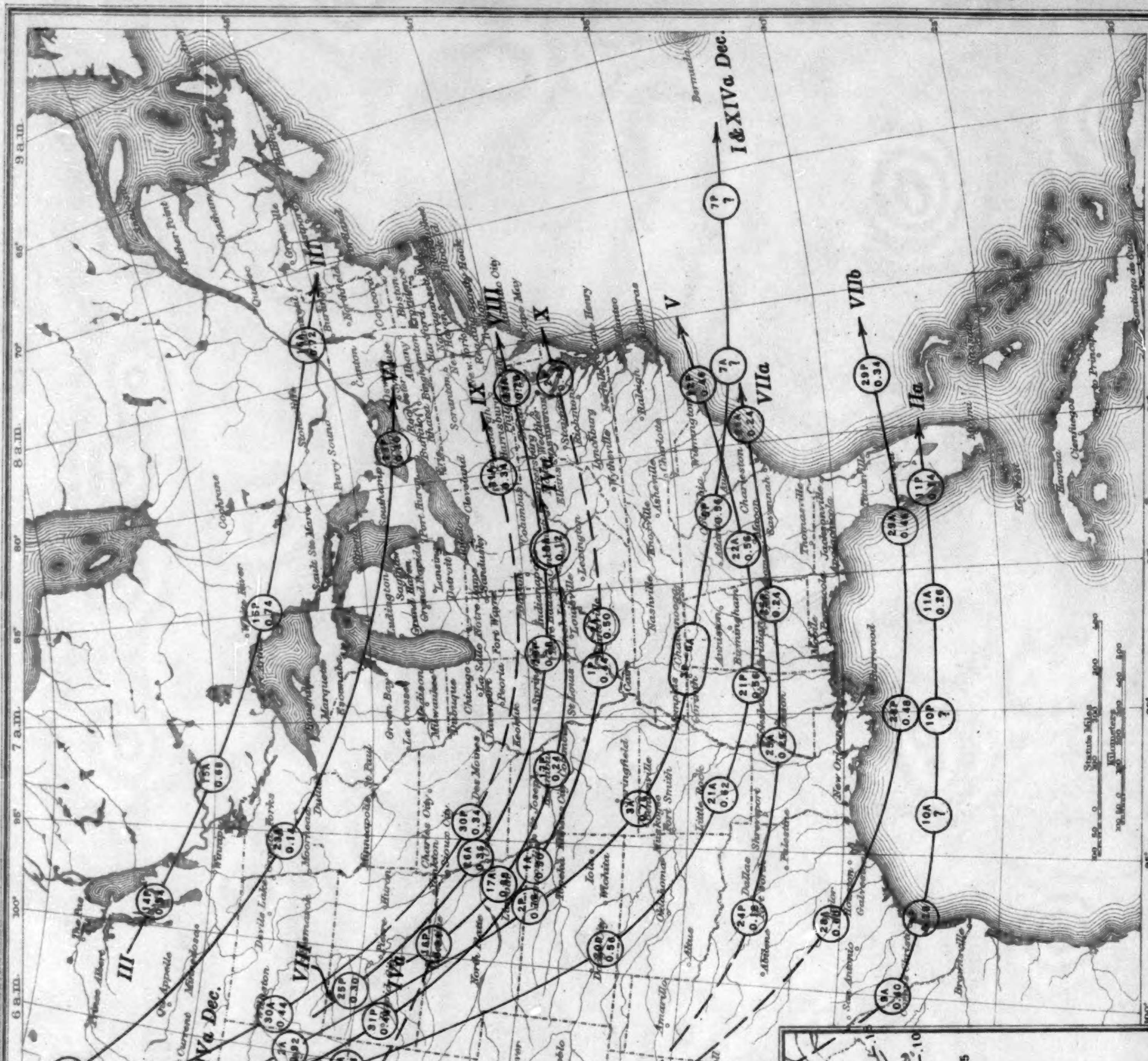
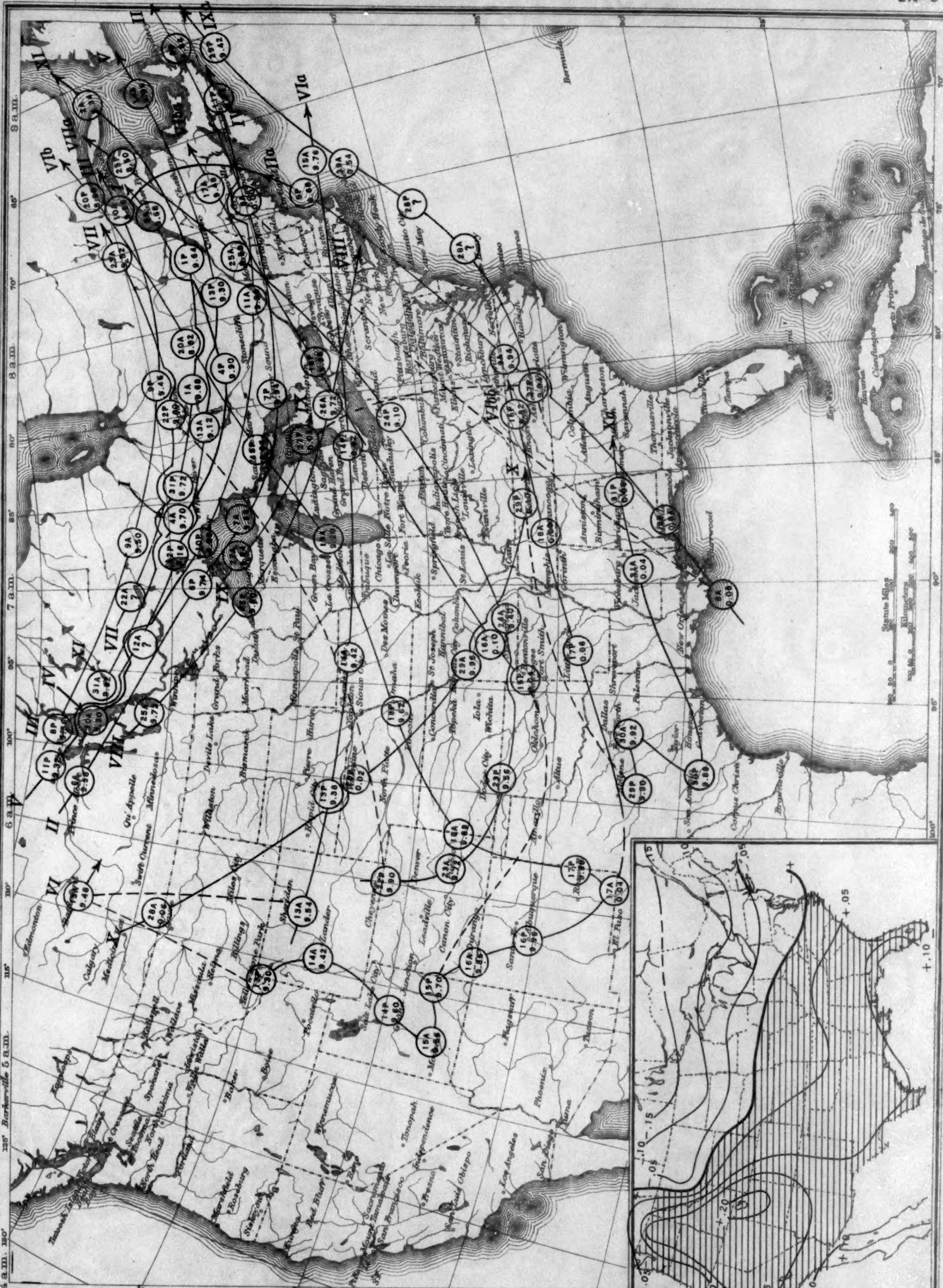


Chart III. Tracks of Centers of Cyclones, January, 1928. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Wilfred P. Day)



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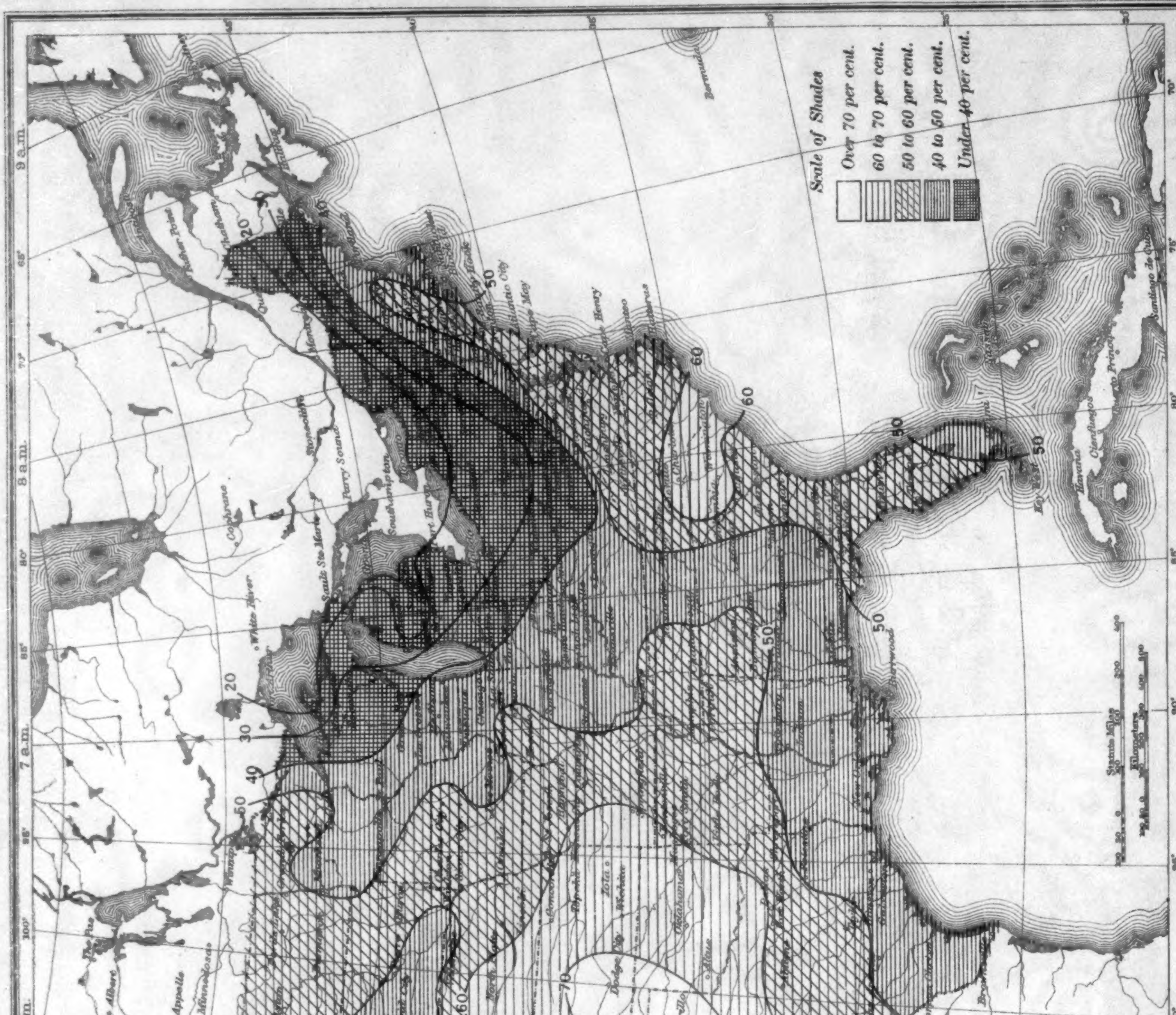

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, January, 1928

Chart V. Total Precipitation, Inches, January, 1928. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, January, 1928. (Inset) Departure of Precipitation from Normal

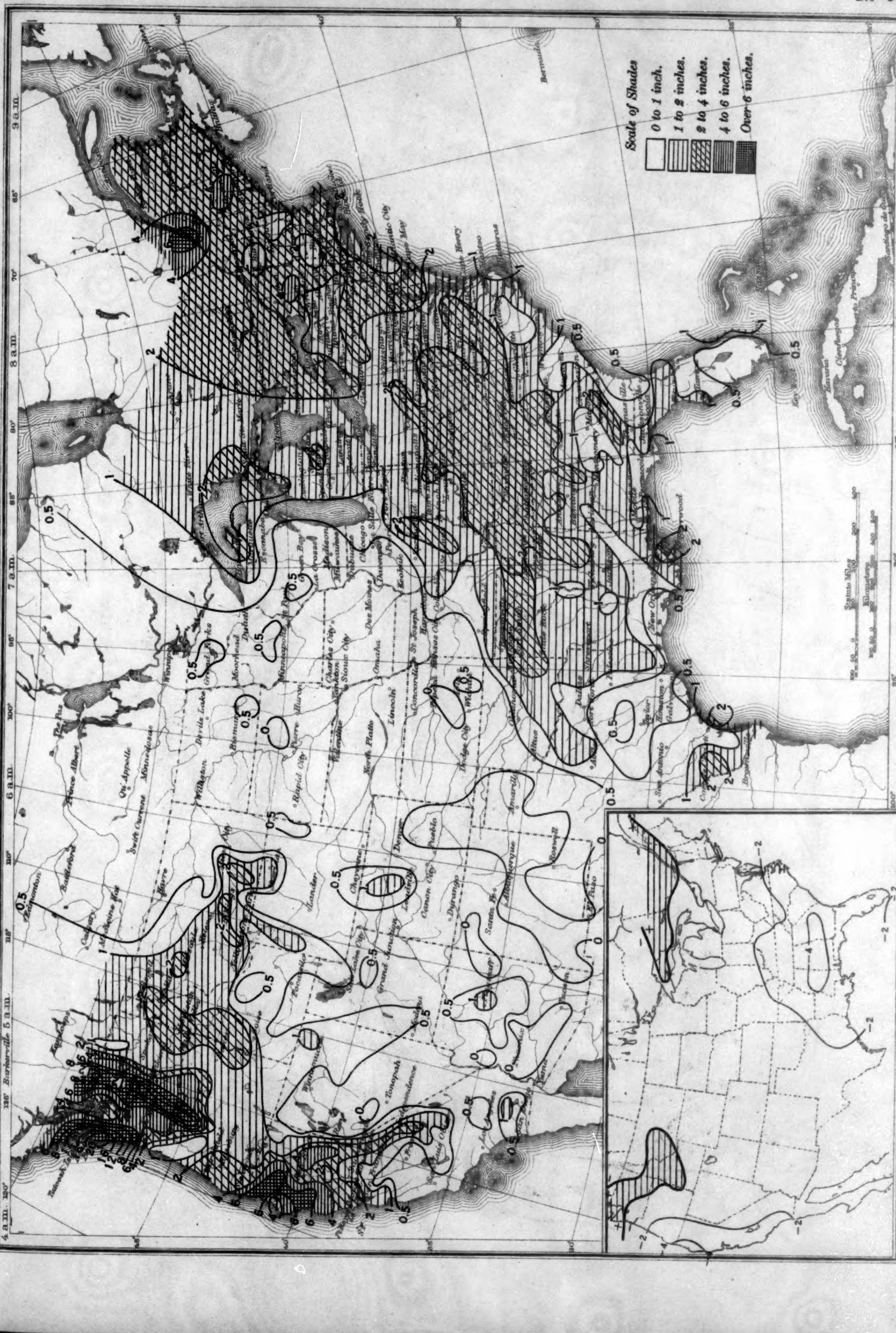

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, January, 1928

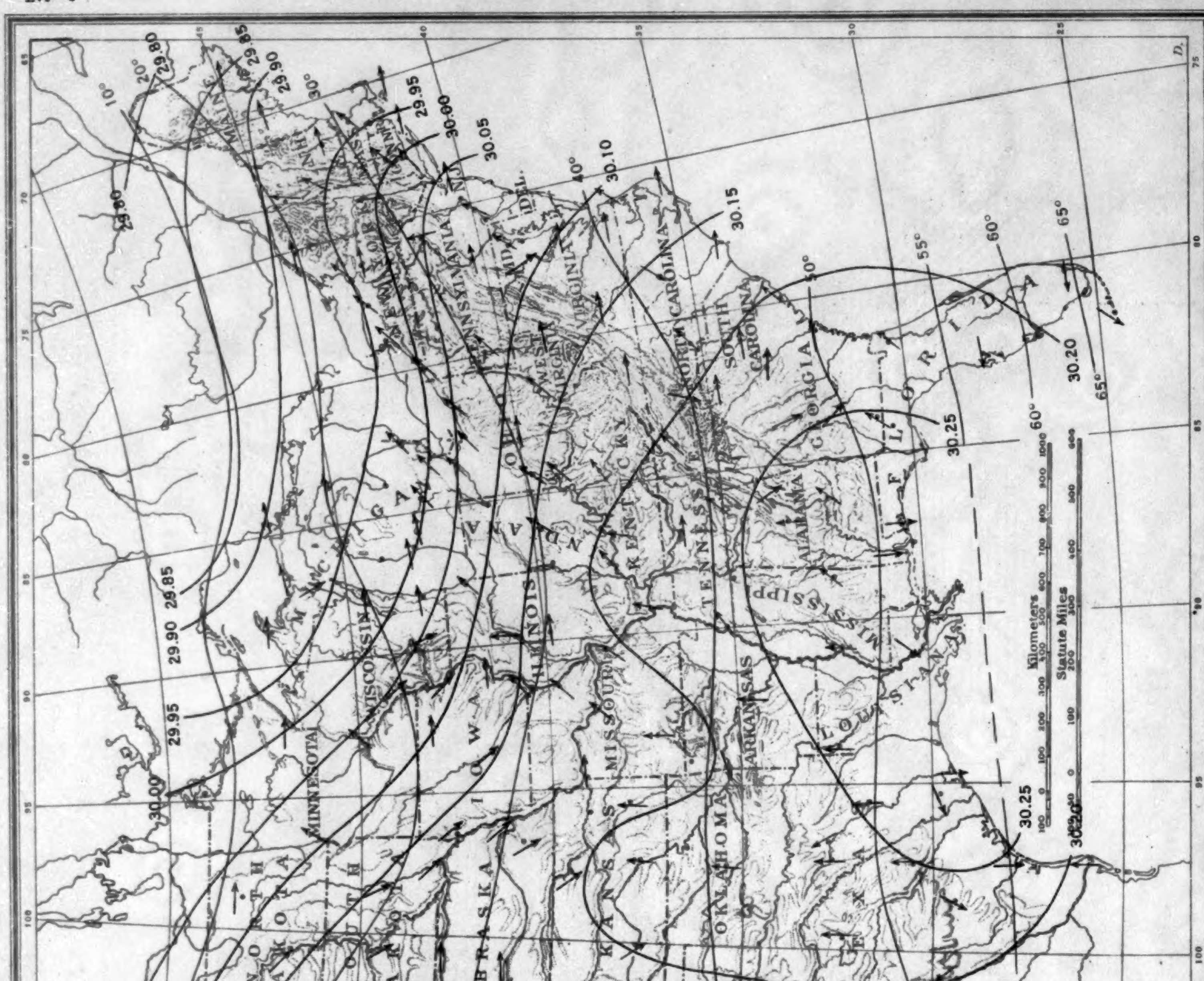

Chart VII. Total Snowfall, Inches, January, 1928. (Inset) Depth of Snow on Ground at end of Month

Chart VIII. Weather Map of North Atlantic Ocean, January 21, 1928

Chart VIII. Weather Map of North Atlantic Ocean, January 21, 1928

(Plotted by F. A. Young)

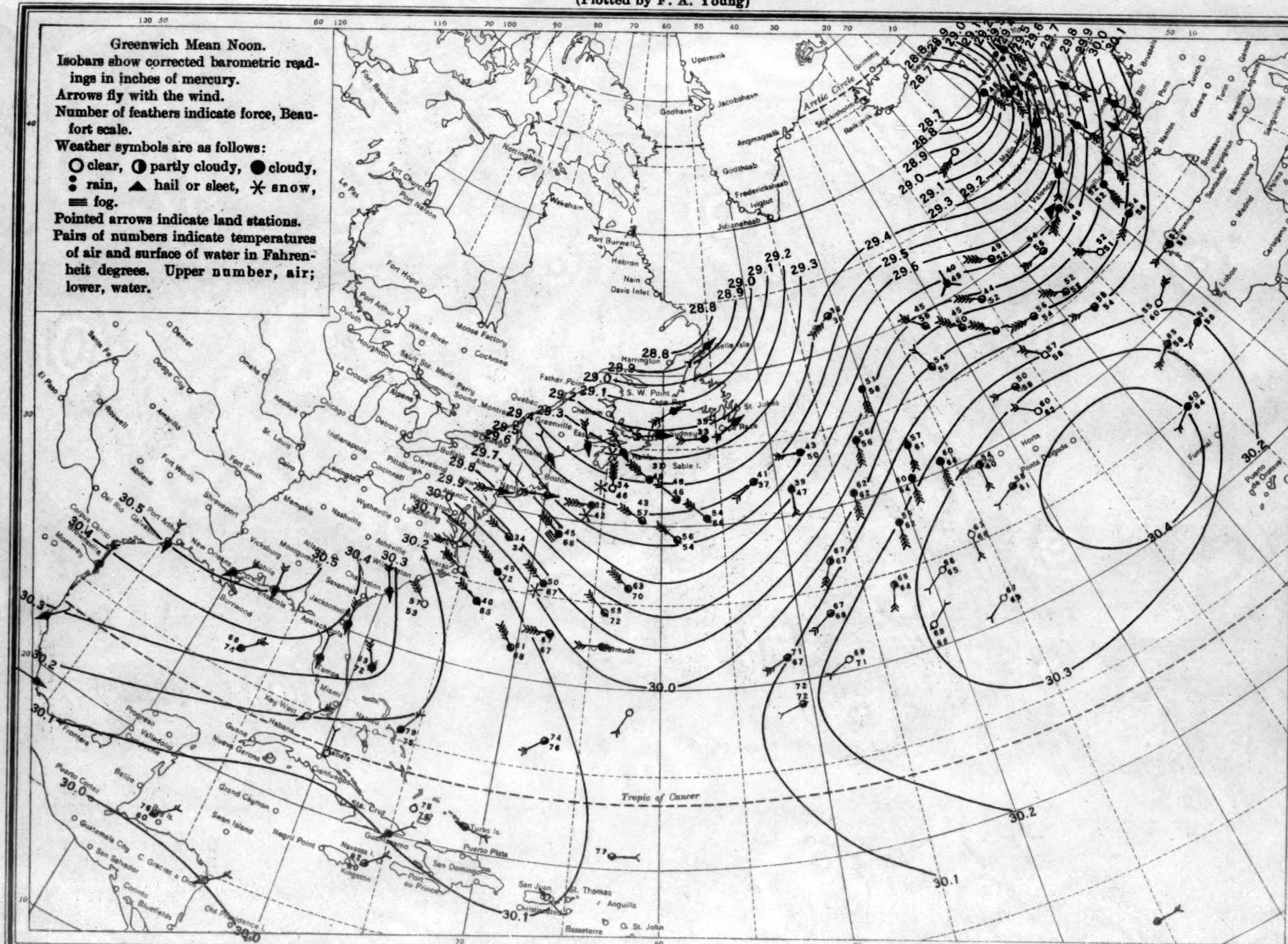

Chart IX. Weather Map of North Atlantic Ocean, January 22, 1928

(Plotted by F. A. Young)

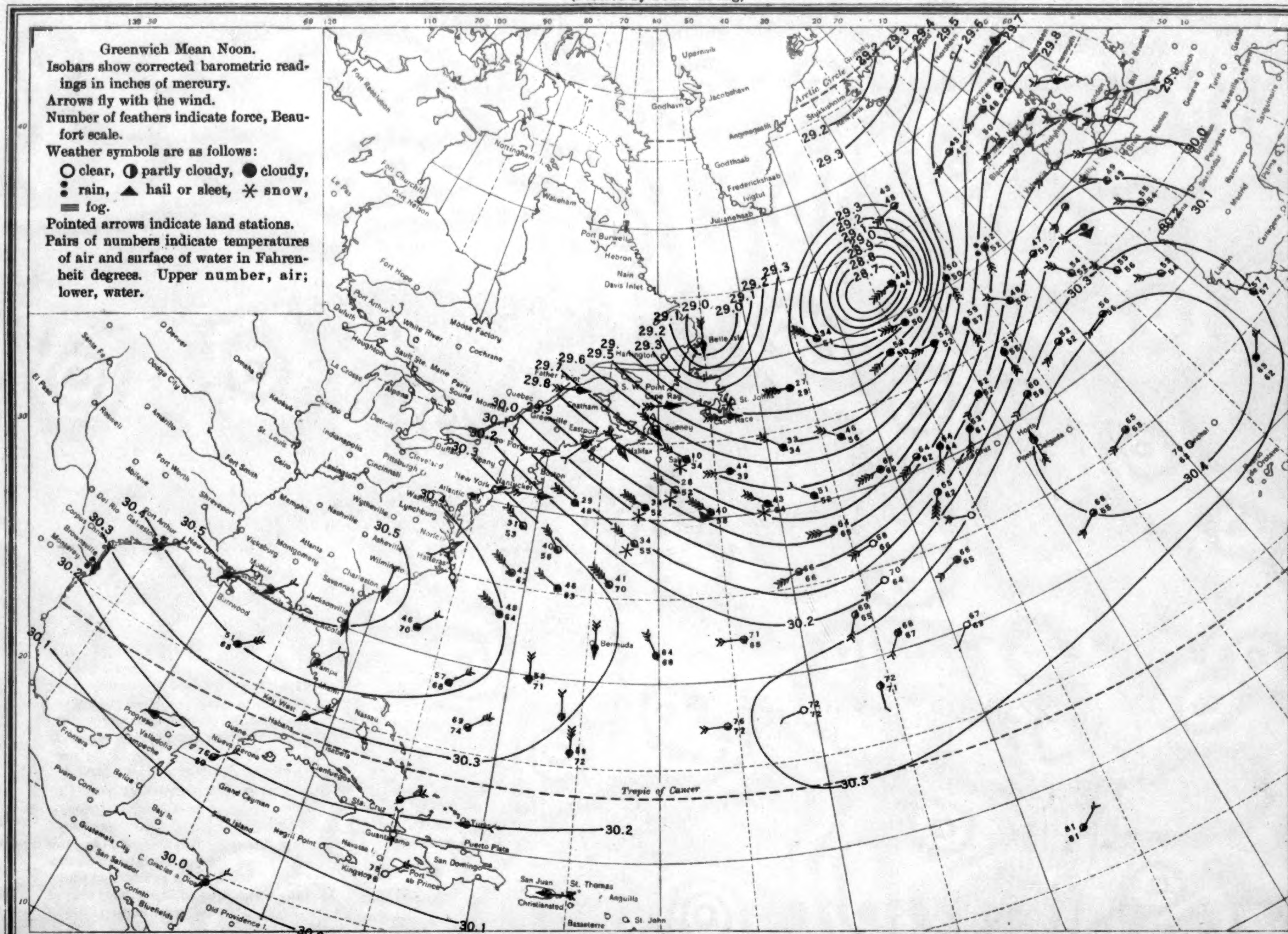

Chart X. Weather Map of North Atlantic Ocean, January 23, 1928

Chart X. Weather Map of North Atlantic Ocean, January 23, 1928
(Plotted by F. A. Young)

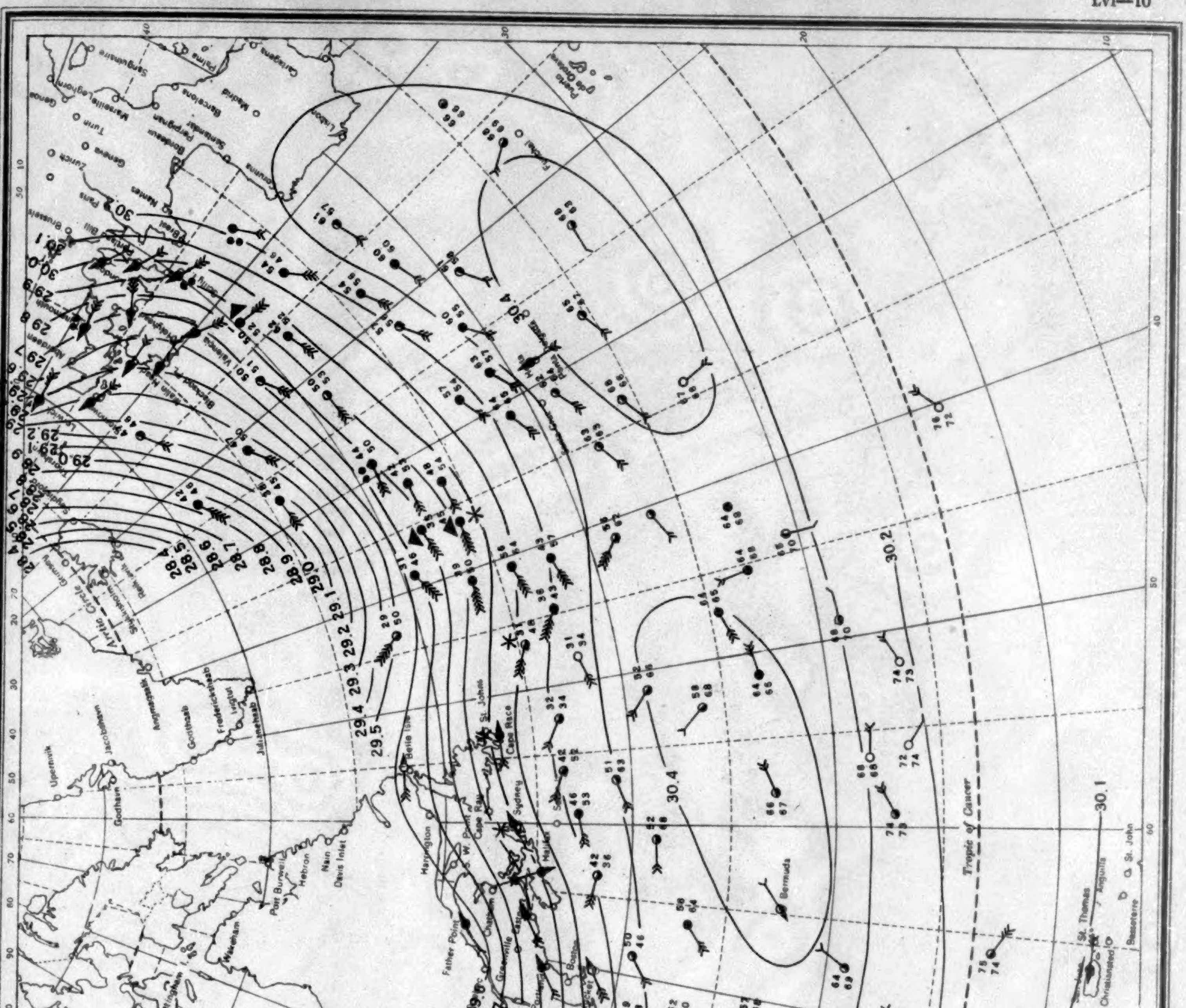

Chart XI. Weather Map of North Atlantic Ocean, January 24, 1928

(Plotted by F. A. Young)

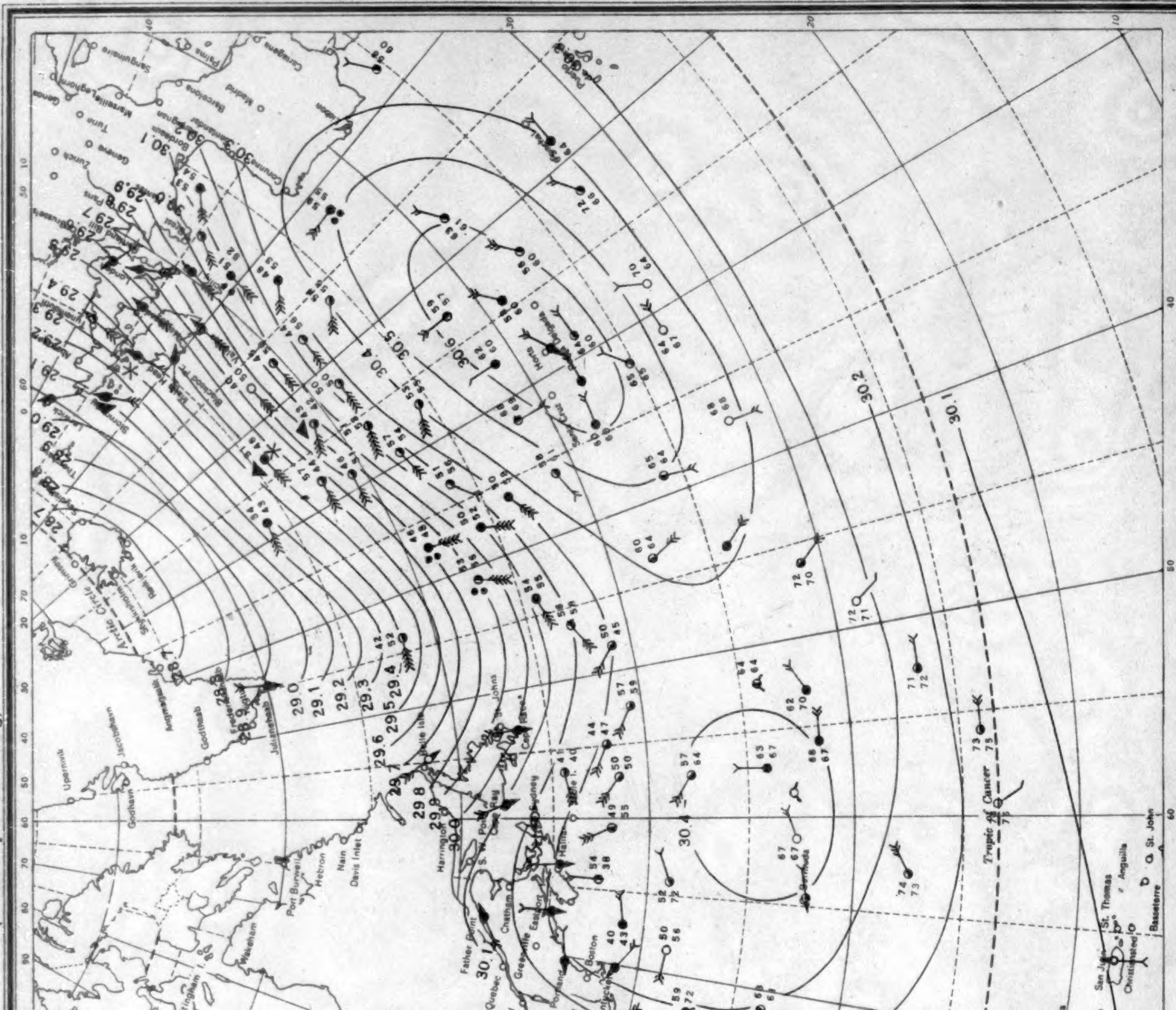

Chart XII. Weather Map of North Atlantic Ocean, January 25, 1928
(Plotted by F. A. Young)

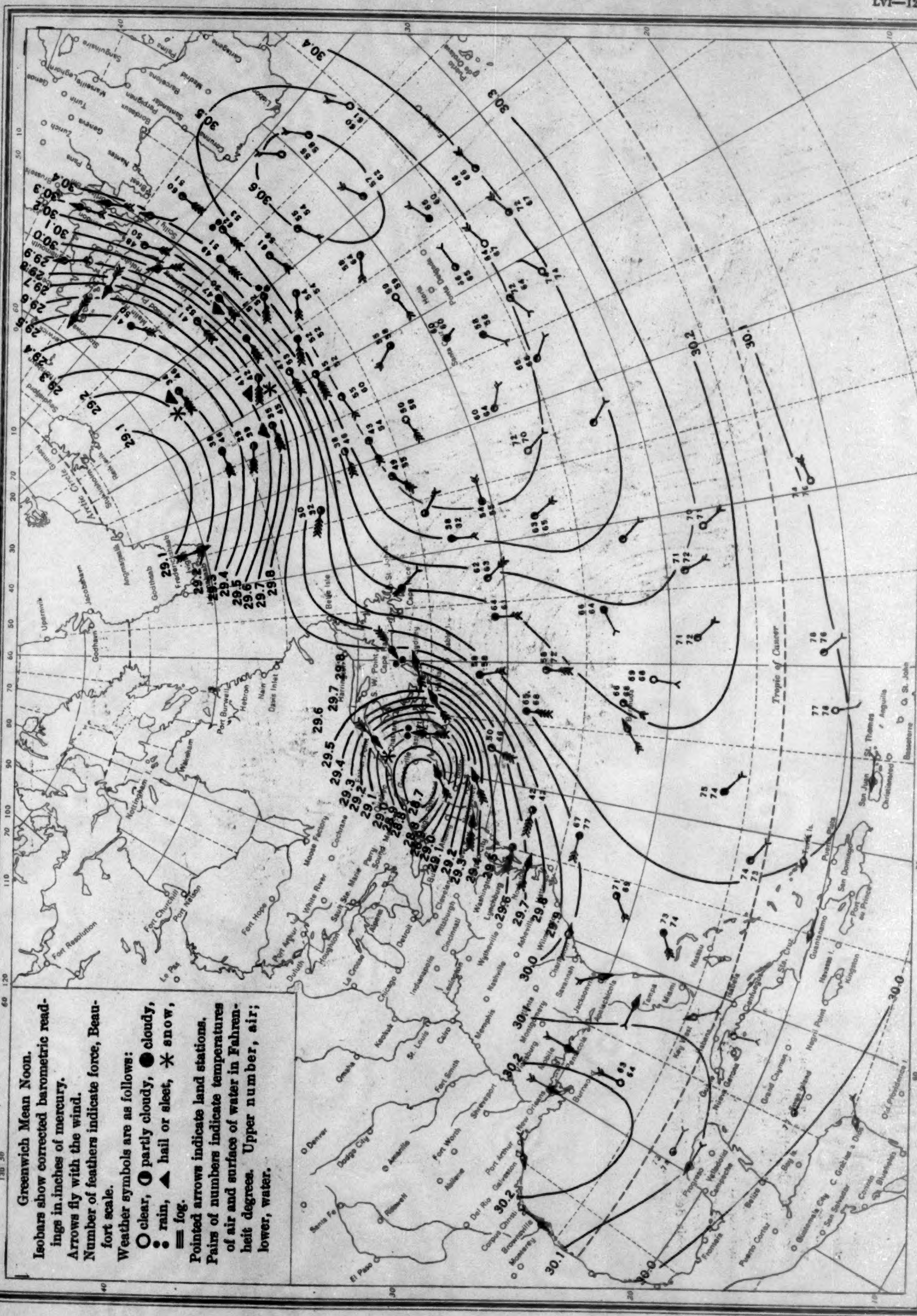

Chart XIII. Weather Map of North Atlantic Ocean, January 26, 1928

(Plotted by F. A. Young)